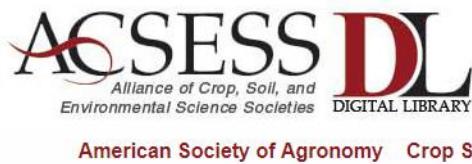


Enzyme-environment

<https://dl.sciencesocieties.org/>



American Society of Agronomy Crop Sci

1,

<https://dl.sciencesocieties.org/publications/jeq/abstracts/20/3/JEQ0200030510>

Use of Enzymes to Detoxify Pesticide-Contaminated Soils and Waters

Applying enzymes to transform or degrade pesticides is an innovative treatment technique for removal of these chemicals from polluted environments. Enzyme-catalyzed degradation of a pollutant by a parathion hydrolase may be more effective than existing chemical methods. Removal of certain pollutants (for instance phenols and aromatic amines) from wastewater may be achieved by applying phenoloxidases that can convert these chemicals to water-insoluble polymers that can then be removed by filtration or sedimentation. Another decontamination method involves the enzyme-catalyzed incorporation of pesticides into organic matter. This procedure reduces the amount of leachable pesticides as well as the toxicity and bioavailability of the chemicals. Pesticide-detoxifying enzymes must be immobilized before they can be used in the environment. In spite of promising potential applications, very few enzymes have been tested as possible tools in the detoxification of pesticides. Research in this domain can contribute greatly to developing new methods for pollution control.

Subscription to get full view.

2,

<https://www.tandfonline.com/doi/abs/10.1080/1522651020850008>

Conjugating Enzymes Involved in Xenobiotic Metabolism of Organic Xenobiotics in Plants

Phytoremediation of organic pollutants has become a topic of great interest in many countries due to the increasing number of recorded spill sites.

When applying plant remediation techniques to unknown pollutant mixtures, information on the uptake rates as well as on the final fate of the compounds is generally lacking. A range of compounds are easily taken up by plants, whereas others may stay motionless and recalcitrant in the soil or sediment. Uptake is a necessary prerequisite for close contact between the pollutant and the detoxifying enzymes of plants that are localized in the cytosol of living cells. The presence and activity of these enzymes is crucial for a potential metabolism and further degradation of the chemicals under consideration. Conjugation to biomolecules is regarded as a beneficial detoxification reaction. The present review summarizes several prerequisites for pollutant uptake and discusses information on conjugating detoxification reactions. The final fate of compounds is critically discussed and perspectives for phytoremediation are given.

3,

<https://www.tandfonline.com/doi/abs/10.1080/07388550490493726>

Utilization of Enzymes for Environmental Applications

Enzymes are powerful tools that help sustain a clean environment in several ways. They are utilized for environmental purposes in a number of industries including agro-food, oil, animal feed, detergent, pulp and paper, textile, leather, petroleum, and specialty chemical and biochemical industry. Enzymes also help to maintain an unpolluted environment through their use in waste management. Recombinant DNA technology, protein engineering, and rational enzyme design are the emerging areas of research pertaining to environmental applications of enzymes. The future will also see the employment of various technologies including gene shuffling, high throughput screening, and nanotechnology. This article presents an overview of the enzymatic applications in pollution control and the promising research avenues in this area.

4,

https://link.springer.com/chapter/10.1007/978-1-4612-2890-5_1

Bacterial and Enzymatic Bioassays for Toxicity Testing in the Environment

More than 50,000 chemicals, most of which are xenobiotics, are in common use and new ones are continually and regularly added to the inventory. Serious concern has been raised over the release of these xenobiotics or their metabolites (Liu et al. 1990) into the environment. Their deleterious effect on the environment can be assessed via acute and chronic toxicity tests, using mostly fish and invertebrate bioassays (Peltier and Weber 1985). However, due to the large number of chemicals to be tested, ecotoxicologists and environmental scientists and engineers are now using short-term toxicity assays which are mostly based on inhibition of the activity of enzymes, bacteria, fungi, algae, and protozoa (Bitton 1983; Bitton and Dutka 1986; Dutka and Bitton 1986; Bitton et al. 1989; Liu and Dutka 1984). Microbial bioassays have been used for screening the toxicity of wastewater effluents and for monitoring the quality of reclaimed water (Grabow et al. 1985).

5,

Reviews of Environmental Contamination and Toxicology

Continuation of Residue Reviews

Book Series

There are [237 volumes](#) in this series

Published 1963 - 2019

Contains [online first chapters](#)



About this series

Reviews of Environmental Contamination and Toxicology publishes reviews pertaining to the sources, transport, fate and effects of contaminants in the environment. The series provides a place for the publication of critical reviews of the current knowledge and understanding of environmental sciences in order to provide insight into contaminant pathways, fate and behavior in environmental compartments and the possible consequences of their presence, with multidisciplinary contributions from the fields of analytical chemistry, biochemistry, biology, ecology, molecular and cellular biology (in an environmental context), and human, wildlife and environmental toxicology. This book series does not typically consider submissions dealing with technical aspects of occupational exposure and effects in humans, wastewater treatment and effluent characterization, or remediation of contaminated sites. However, submissions addressing one of these topic areas may be considered where there exists a strong link to the receiving environment, and/or the identification of emerging contaminants of concern. All manuscripts will be peer-reviewed by experts in the field. Reviewers will be asked to consider coverage and critical appraisal of the subject, originality, relevance, and impact to the wider scientific community. Authors writing in a second language are encouraged to have their manuscript corrected by a native English speaker or by a professional editing firm. Abstracts, short communications and notes will not be accepted. Where appropriate, such submissions may be referred to our companion journal, the Bulletin of Environmental Contamination and Toxicology (BECT), while full-length research articles are typically the purview of Archives of Environmental Contaminant and Toxicology (AECT). RECT prefers extended reviews of a length including references of more than 5,000 words, and without an upper word count limit. Reviews of shorter length (i.e. where length including references of less than 5,000 words) which may be suitable for case studies, a focused topic or an applied subject of debate or interest can be submitted to AECT. Authors may directly contact the Editor-in-Chief if they wish to clarify which publication is most suited for their submission. There is now the option to publish your chapter as **open access** within **Reviews of Environmental Contamination and Toxicology**. Please contact us for details.

Impact Factor: 7.00 (2017) *

Subject category

"Environmental sciences": Rank 10 of 241

"Toxicology": Rank 3 of 94

* Journal Citation Reports®, Clarivate Analytics

Editor-in-Chief:

Pim de Voogt

University of Amsterdam, Amsterdam, The Netherlands

RECT-science@uva.nl

Editorial Assistant:

Helen Bergman

University of Amsterdam, Amsterdam, The Netherlands

RECT-science@uva.nl

Editorial Board:

María Fernanda Cavieres, University of Valparaíso, Valparaíso, Chile; James B. Knaak, Fort Myers, FL, USA; Annemarie P. van Wezel, University of Amsterdam, Amsterdam, The Netherlands; Ronald S. Tjeerdema, University of California, Davis, CA, USA, Marco Vighi, IMDEA Water Institute, Madrid, Spain

6,

<https://www.sciencedirect.com/science/article/pii/S0167779906000990>

novel green

Miguel Alcalde, Manuel Ferrer, Francisco J. Plou, Antonio Ballesteros 

Departamento de Biocatálisis, Instituto de Catálisis y Petroleoquímica,
CSIC, Cantoblanco, 28049 Madrid, Spain

Modern biocatalysis is developing new and precise tools to improve a wide range of production processes, which reduce energy and raw material consumption and generate less waste and toxic side-products. Biocatalysis is also achieving new advances in environmental fields, from enzymatic bioremediation to the synthesis of renewable and clean energies and biochemical cleaning of ‘dirty’ fossil fuels. Despite the obvious benefits of biocatalysis, the major hurdles hindering the exploitation of the repertoire of enzymatic processes are, in many cases, the high production costs and the low yields obtained. This article will discuss these issues, pinpointing specific new advances in recombinant DNA techniques amenable to future biocatalyst development, in addition to drawing the attention of the biotechnology community to the active pursuit and development of environmental biocatalysis, from remediation with enzymes to novel green processes.

References

1.
 - Sheldon R.A.
 - van Rantwijk F.

Biocatalysis for sustainable organic synthesis.

Aust. J. Chem. 2004; **57**: 281-289

[View in Article](#)

- [Scopus \(52\)](#)
- [Crossref](#)

- [Google Scholar](#)
- 2.
- Paul D.
- et al.

Accessing microbial diversity for bioremediation and environmental restoration.

Trends Biotechnol. 2005; **23**: 135-142

[View in Article](#)

- [Scopus \(109\)](#)
- [PubMed](#)
- [Abstract](#)
- [Full Text](#)
- [Full Text PDF](#)
- [Google Scholar](#)
- 3.
- Sutherland T.D.
- et al.

Enzymatic bioremediation: from enzyme discovery to applications.

Clin. Exp. Pharmacol. Physiol. 2004; **31**: 817-821

[View in Article](#)

- [Scopus \(79\)](#)
- [PubMed](#)
- [Crossref](#)
- [Google Scholar](#)
- 4.
- Poliakoff M.
- et al.

Green chemistry: science and politics of change.

Science. 2002; **297**: 807-810

[View in Article](#)

- [Scopus \(578\)](#)
- [PubMed](#)
- [Crossref](#)
- [Google Scholar](#)
- 5.
- Mertens R.
- Liese A.

Biotechnological applications of hydrogenases.

Curr. Opin. Biotechnol. 2004; **15**: 343-348

[View in Article](#)

- [Scopus \(85\)](#)
 - [PubMed](#)
 - [Crossref](#)
 - [Google Scholar](#)
- 6.
- Ahuja S.K.
 - et al.

Utilization of enzymes for environmental applications.

Crit. Rev. Biotechnol. 2004; **24**: 125-154

[View in Article](#)

- [Scopus \(77\)](#)
 - [PubMed](#)
 - [Crossref](#)
 - [Google Scholar](#)
- 7.
- Anastas P.
 - Williamson T.

Green Chemistry. Theory and Practice.

Oxford University Press, ; 1998

[View in Article](#)

- [Google Scholar](#)
- 8.
- Armor J.N.

Striving for catalytically green processes in the 21st century.

Appl. Catal A: Gen. 1999; **189**: 153-162

[View in Article](#)

- [Scopus \(45\)](#)
 - [Crossref](#)
 - [Google Scholar](#)
- 9.
- Lenardao E.J.
 - et al.

Green chemistry – the 12 principles of green chemistry and its insertion in the teach and research activities.

Quim. Nova. 2003; **26**: 123-129

[View in Article](#)

- [Scopus \(100\)](#)
- [Crossref](#)
- [Google Scholar](#)

10.

- Azerad R.

Chemical biotechnology – better enzymes for green chemistry. Editorial overview.

Curr. Opin. Biotechnol. 2001; **12**: 533-534

[View in Article](#)

- [Scopus \(19\)](#)
- [Crossref](#)
- [Google Scholar](#)

11.

- Khosla C.
- Harbury P.B.

Modular enzymes.

Nature. 2001; **409**: 247-252

[View in Article](#)

- [Scopus \(99\)](#)
- [PubMed](#)
- [Crossref](#)
- [Google Scholar](#)

12.

- Walsh C.

Enabling the chemistry of life.

Nature. 2001; **409**: 226-231

[View in Article](#)

- [Scopus \(106\)](#)
- [PubMed](#)
- [Crossref](#)
- [Google Scholar](#)

13.

- Bull A.T.

- et al.

Biocatalysts for clean industrial products and processes.

Curr. Opin. Microbiol. 1999; **2**: 246-251

[View in Article](#)

- [Scopus \(37\)](#)
- [PubMed](#)
- [Crossref](#)
- [Google Scholar](#)

14.

- Schmid A.
- et al.

Industrial biocatalysis today and tomorrow.

Nature. 2001; **409**: 258-268

[View in Article](#)

- [Scopus \(1655\)](#)
- [PubMed](#)
- [Crossref](#)
- [Google Scholar](#)

15.

- Steinbuchel A.

Non-biodegradable biopolymers from renewable resources: perspectives and impacts.

Curr. Opin. Biotechnol. 2005; **16**: 607-613

[View in Article](#)

- [Scopus \(62\)](#)
- [PubMed](#)
- [Crossref](#)
- [Google Scholar](#)

16.

- Gübitz G.M.
- et al.

Enzymes in fibre processing.

Biocatal. Biotransform. 2004; **22**: 299-400

[View in Article](#)

- [Scopus \(27\)](#)
- [Crossref](#)

- [Google Scholar](#)

17.

- Bajpai P.

Biological bleaching of chemical pulps.

Crit. Rev. Biotechnol. 2004; **24**: 1-58

[View in Article](#)

- [Scopus \(129\)](#)

- [PubMed](#)

- [Crossref](#)

- [Google Scholar](#)

18.

- Bode H.B.
- Müller R.

The impact of bacterial genomics on natural product research.

Angew. Chem. Int. Ed. Engl. 2005; **44**: 6828-6846

[View in Article](#)

- [Scopus \(176\)](#)

- [PubMed](#)

- [Crossref](#)

- [Google Scholar](#)

19.

- Bornscheuer U.T.
- Kazlauskas R.J.

Catalytic promiscuity in biocatalysis: using old enzymes to form new bonds and follow new pathways.

Angew. Chem. Int. Ed. Engl. 2004; **43**: 6032-6040

[View in Article](#)

- [Scopus \(390\)](#)

- [PubMed](#)

- [Crossref](#)

- [Google Scholar](#)

20.

- Glieder A.
- et al.

Comprehensive step-by-step engineering of an (R)-hydroxynitrile lyase for large-scale asymmetric synthesis.

Angew. Chem. Int. Ed. Engl. 2003; **42**: 4815-4818

[View in Article](#)

- [Scopus \(89\)](#)
 - [PubMed](#)
 - [Crossref](#)
 - [Google Scholar](#)
- 21.
- Lee S.Y.
 - et al.

Systems biotechnology for strain improvement.

Trends Biotechnol. 2005; **23**: 349-358

[View in Article](#)

- [Scopus \(229\)](#)
- [PubMed](#)
- [Abstract](#)
- [Full Text](#)
- [Full Text PDF](#)
- [Google Scholar](#)

22.

- Cao L.

Immobilised enzymes: science or art.

Curr. Opin. Chem. Biol. 2005; **9**: 217-226

[View in Article](#)

- [Scopus \(468\)](#)
- [PubMed](#)
- [Crossref](#)
- [Google Scholar](#)

23.

- Handelsman J.

Metagenomics: application of genomics to uncultured microorganisms.

Microbiol. Mol. Biol. Rev. 2004; **68**: 669-685

[View in Article](#)

- [Scopus \(1164\)](#)
- [PubMed](#)
- [Crossref](#)
- [Google Scholar](#)

24.

- Cowan D.

- et al.

Metagenomic gene discovery: past, present and future.

Trends Biotechnol. 2005; **23**: 321-332

[View in Article](#)

- [Scopus \(174\)](#)
- [PubMed](#)
- [Abstract](#)
- [Full Text](#)
- [Full Text PDF](#)
- [Google Scholar](#)

25.

- Ferrer M.
- et al.

Mining genomes and metagenomes for novel catalysts.

Curr. Opin. Biotechnol. 2005; **16**: 588-593

[View in Article](#)

- [Scopus \(105\)](#)
- [PubMed](#)
- [Crossref](#)
- [Google Scholar](#)

26.

- El Fantroussi S.
- Agathos S.N.

Is bioaugmentation a feasible strategy for pollutant removal and site remediation?.

Curr. Opin. Microbiol. 2005; **8**: 268-275

[View in Article](#)

- [Scopus \(321\)](#)
- [PubMed](#)
- [Crossref](#)
- [Google Scholar](#)

27.

- Thompson I.P.
- et al.

Bioaugmentation for bioremediation: the challenge of strain selection.

Environ. Microbiol. 2005; **7**: 909-915

[View in Article](#)

- [Scopus \(227\)](#)
- [PubMed](#)
- [Crossref](#)
- [Google Scholar](#)

28.

- Marques M.
- Hogland W.

Hydrological performance of MSW incineration residues and MSW co-disposed with sludge in full-scale cells.

Waste Manag. 2003; **23**: 469-481

[View in Article](#)

- [Scopus \(1\)](#)
- [PubMed](#)
- [Crossref](#)
- [Google Scholar](#)

29.

- Ford C.Z.
- et al.

Containment of a genetically engineered microorganism during a field bioremediation application.

Appl. Microbiol. Biotechnol. 1999; **51**: 397-400

[View in Article](#)

- [Scopus \(26\)](#)
- [PubMed](#)
- [Crossref](#)
- [Google Scholar](#)

30.

- Scow K.M.
- Hicks K.A.

Natural attenuation and enhanced bioremediation of organic contaminants in groundwater.

Curr. Opin. Biotechnol. 2005; **16**: 246-253

[View in Article](#)

- [Scopus \(114\)](#)
- [PubMed](#)
- [Crossref](#)
- [Google Scholar](#)

31.

- Pieper D.H.

- et al.

Genomic and mechanistic insight into the biodegradation of organic pollutants.

Curr. Opin. Biotechnol. 2004; **15**: 215-224

[View in Article](#)

- [Scopus \(80\)](#)
- [PubMed](#)
- [Crossref](#)
- [Google Scholar](#)

32.

- Samanta S.K.

Polycyclic aromatic hydrocarbons: environmental pollution and bioremediation.

Trends Biotechnol. 2002; **20**: 243-248

[View in Article](#)

- [Scopus \(637\)](#)
- [PubMed](#)
- [Abstract](#)
- [Full Text](#)
- [Full Text PDF](#)
- [Google Scholar](#)

33.

- Ramos J.L.
- et al.

Bioremediation of polynitrated aromatic compounds: plants and microbes put up a fight.

Curr. Opin. Biotechnol. 2005; **16**: 275-281

[View in Article](#)

- [Scopus \(72\)](#)
- [PubMed](#)
- [Crossref](#)
- [Google Scholar](#)

34.

- Arnold F.H.

Combinatorial and computational challenges for biocatalysts design.

Nature. 2001; **409**: 253-257

[View in Article](#)

- [Scopus \(310\)](#)

- [PubMed](#)
- [Crossref](#)
- [Google Scholar](#)

35.

- Tao H.
- Cornish V.W.

Milestones in directed enzyme evolution.

Curr. Opin. Chem. Biol. 2002; **6**: 858-864

[View in Article](#)

- [Scopus \(117\)](#)
- [PubMed](#)
- [Crossref](#)
- [Google Scholar](#)

36.

- Chica R.A.
- et al.

Semi-rational approaches to engineering enzyme activity: combining the benefits of directed evolution and rational design.

Curr. Opin. Biotechnol. 2005; **16**: 378-384

[View in Article](#)

- [Scopus \(210\)](#)
- [PubMed](#)
- [Crossref](#)
- [Google Scholar](#)

37.

- Raillard S.
- et al.

Novel enzyme activities and functional plasticity revealed by recombining highly homologous enzymes.

Chem. Biol. 2001; **8**: 891-898

[View in Article](#)

- [Scopus \(87\)](#)
- [PubMed](#)
- [Abstract](#)
- [Full Text](#)
- [Full Text PDF](#)
- [Google Scholar](#)

38.

- Cho C.M.H.
- et al.

Bacterial cell surface display of organophosphorous hydrolase for selective screening of improved hydrolysis of organophosphate nerve agent.

Appl. Environ. Microbiol. 2002; **68**: 2026-2030

[View in Article](#)

- [Scopus \(138\)](#)
 - [PubMed](#)
 - [Crossref](#)
 - [Google Scholar](#)
- 39.
- Yang H.
 - et al.

Evolution of an organophosphate-degrading enzyme: a comparison of natural and directed evolution.

Protein Eng. 2003; **16**: 135-145

[View in Article](#)

- [PubMed](#)
 - [Crossref](#)
 - [Google Scholar](#)
- 40.
- Mohammadi M.
 - Sylvestre M.

Resolving the profile metabolites generated during oxidation of dibenzofuran and chlorodibenzofurans by the biphenyl catabolic pathway enzymes.

Chem. Biol. 2005; **12**: 835-846

[View in Article](#)

- [Scopus \(27\)](#)
- [PubMed](#)
- [Abstract](#)
- [Full Text](#)
- [Full Text PDF](#)
- [Google Scholar](#)

41. Mencia, M. *et al.* Obtention of a hexachlorocyclohexane dehydrochlorinase (LinA) variant with improved expression and solubility properties. *Biocatal. Biotransform.* (in press)

[View in Article](#)

- [Google Scholar](#)

42.

- Bulter T.
- et al.

Functional expression of a fungal laccase in *Saccharomyces cerevisiae* by directed evolution.

Appl. Environ. Microbiol. 2003; **69**: 987-995

[View in Article](#)

- [Scopus \(197\)](#)
- [PubMed](#)
- [Crossref](#)
- [Google Scholar](#)

43.

- Torres E.
- et al.

Potential use of oxidative enzymes for the detoxification of organic pollutants.

Appl. Catal. B: Environ. 2003; **46**: 1-15

[View in Article](#)

- [Scopus \(277\)](#)
- [Crossref](#)
- [Google Scholar](#)

44.

- Alcalde M.
- et al.

Screening mutant libraries of fungal laccases in the presence of organic solvents.

J. Biomol. Screen. 2005; **10**: 624-631

[View in Article](#)

- [Scopus \(44\)](#)
- [PubMed](#)
- [Crossref](#)
- [Google Scholar](#)

45.

- Camarero S.
- et al.

Lignin-derived compounds as efficient laccase mediators for decolorization of different types of recalcitrant dyes.

Appl. Environ. Microbiol. 2005; **71**: 1775-1784

[View in Article](#)

- o [Scopus \(406\)](#)
- o [PubMed](#)
- o [Crossref](#)
- o [Google Scholar](#)

46.

- o Ward O.P.
- o Singh A.

Bioethanol technology: developments and perspectives.

Adv. Appl. Microbiol. 2002; **51**: 53-80

[View in Article](#)

- o [Scopus \(66\)](#)
- o [PubMed](#)
- o [Crossref](#)
- o [Google Scholar](#)

47.

- o Pessoa Jr, A.
- o et al.

Perspectives on bioenergy and biotechnology in Brazil.

Appl. Biochem. Biotechnol. 2005; **121–124**: 59-70

[View in Article](#)

- o [PubMed](#)
- o [Crossref](#)
- o [Google Scholar](#)

48.

- o Salis A.
- o et al.

Biodiesel production from triolein and short chain alcohols through biocatalysis.

J. Biotechnol. 2005; **119**: 291-299

[View in Article](#)

- o [Scopus \(177\)](#)
- o [PubMed](#)
- o [Crossref](#)
- o [Google Scholar](#)

49.

- MacLean H.L.
- et al.

A life-cycle comparison of alternative automobile fuels.

J. Air Waste Manage. Assoc. 2000; **50**: 1769-1779

[View in Article](#)

- [Scopus \(57\)](#)
- [Crossref](#)
- [Google Scholar](#)

50.

- Jaeger K.E.
- Eggert T.

Lipases for biotechnology.

Curr. Opin. Biotechnol. 2002; **13**: 390-397

[View in Article](#)

- [Scopus \(945\)](#)
- [PubMed](#)
- [Crossref](#)
- [Google Scholar](#)

51.

- Montgomery R.

Development of biobased products.

Bioresour. Technol. 2004; **91**: 1-29

[View in Article](#)

- [Scopus \(76\)](#)
- [PubMed](#)
- [Crossref](#)
- [Google Scholar](#)

52.

- Palmarola-Adrados B.
- et al.

Ethanol production from non-starch carbohydrates of wheat bran.

Bioresour. Technol. 2005; **96**: 843-850

[View in Article](#)

- [Scopus \(118\)](#)
- [PubMed](#)

- [Crossref](#)
- [Google Scholar](#)

53.

- Sommer P.
- et al.

Potential for using thermophilic anaerobic bacteria for bioethanol production from hemicellulose.

Biochem. Soc. Trans. 2004; **32**: 283-289

[View in Article](#)

- [Scopus \(80\)](#)
- [PubMed](#)
- [Crossref](#)
- [Google Scholar](#)

54.

- Zaldivar J.
- et al.

Fuel ethanol production from lignocellulose: a challenge for metabolic engineering and process integration.

Appl. Microbiol. Biotechnol. 2001; **56**: 17-34

[View in Article](#)

- [Scopus \(653\)](#)
- [PubMed](#)
- [Crossref](#)
- [Google Scholar](#)

55.

- Benemann J.

Hydrogen biotechnology: progress and prospects.

Nat. Biotechnol. 1996; **14**: 1101-1103

[View in Article](#)

- [Scopus \(358\)](#)
- [PubMed](#)
- [Crossref](#)
- [Google Scholar](#)

56.

- Kruse O.
- et al.

Photosynthesis: a blueprint from solar energy capture and biohydrogen production technologies.

Photochem. Photobiol. Sci. 2005; **4**: 957-970

[View in Article](#)

- [Scopus \(202\)](#)
- [PubMed](#)
- [Crossref](#)
- [Google Scholar](#)

57.

- Kalia V.C.
- et al.

Mining genomic databases to identify novel hydrogen producers.

Trends Biotechnol. 2003; **21**: 152-156

[View in Article](#)

- [Scopus \(52\)](#)
- [PubMed](#)
- [Abstract](#)
- [Full Text](#)
- [Full Text PDF](#)
- [Google Scholar](#)

58.

- Karyakin A.A.
- et al.

Hydrogen fuel electrode based on biocatalysis by the enzyme hydrogenase.

Electrochim. Commun. 2002; **4**: 417-420

[View in Article](#)

- [Scopus \(56\)](#)
- [Crossref](#)
- [Google Scholar](#)

Article Info

Identification

DOI: <https://doi.org/10.1016/j.tibtech.2006.04.002>

Copyright

© 2006 Elsevier Ltd. Published by Elsevier Inc. All rights reserved.