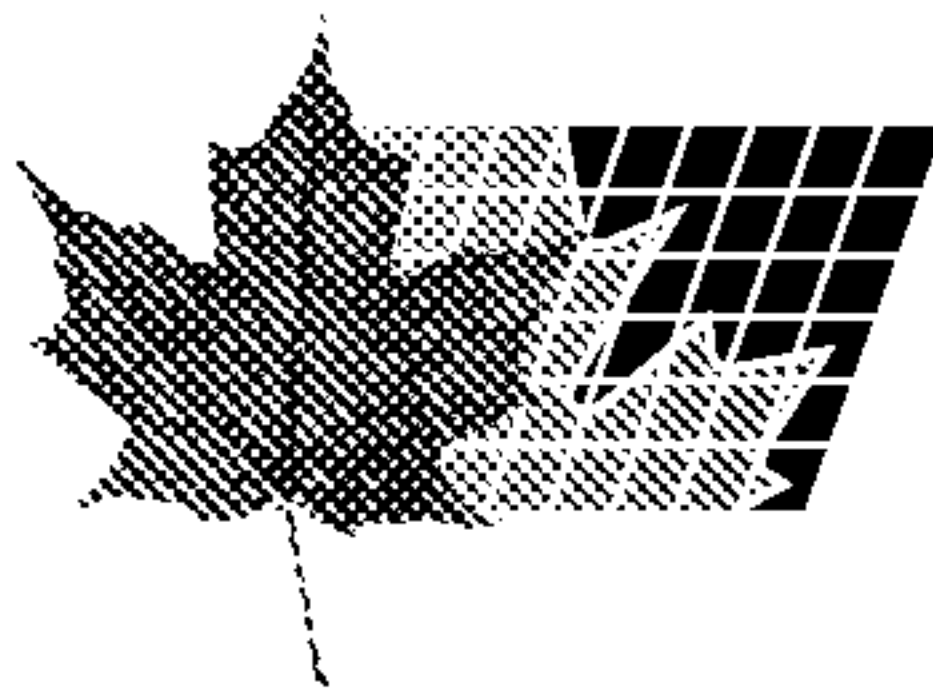




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(54) **METHODE POUR AMELIORER L'ACTIVITE CATALYTIQUE
DE CELLULES**

(54) **METHOD FOR ENHANCING CATALYTIC ACTIVITY OF
CELLS**

(57) Cells showing a reaction rate 350 to 600 times higher than untreated cells can be obtained by treating the cells with a lower alcohol. Namely, cells which have a higher activity than a cell extract and can be recycled can be obtained merely by treating the cells with a low alcohol.

ABSTRACT

Treatment of cells with lower alcohol provides cells having the reaction rate 350 to 600 times higher than that of cells that are not treated with lower alcohol. More specifically, a simple operation of treating cells with lower alcohol provides a catalyst that has a higher activity than that of a cell extract and can be recycled.

DESCRIPTION

METHOD FOR ENHANCING CATALYTIC ACTIVITY OF CELLS

Technical Field

The present invention relates to a method for producing a desired substance using cells as a catalyst. More specifically, the present invention relates to a method for producing a desired substance using cells treated with lower alcohol as a catalyst.

Background Art

There have been attempts to use cells as a catalyst in biological processes as it is. In order to enhance the catalytic activity of the cells, it is necessary to lower the permeability barrier of cell walls, cell membranes or the like. There have been a large number of reports on attempts to lower the permeability barriers of microorganisms to increase the permeability (Felix et al., Ana. Biochem. 120:211-234 (1982)).

For example, the results of research on enhancing the membrane permeability have been reported with respect to yeasts treated with a mixed solution of toluene and ethanol (Serrano Eur. J. Biochem. 34: 479-482 (1973)); cetyltrimethylammonium bromide (Gowda et al., Enzyme Micro. Technol. 13: 154-157 (1991)); ethyl ether (Seip and Cosimo et al., Biotechnol. Bioeng. 40:638-642 (1992)); alcohols (Fenton et al., Enzyme Micro. Technol. 4: 229-232 (1982)); digitonin (Joshi et al., Enzyme Micro. Technol. 11: 439-444 (1989)); Triton X-100 (Vlach et al., J. Mol. Catal. 26:173-185 (1984)); and hexamethylene diamine (Inoue et al., Process biochem. 29: 271-275

(1994)).

However, such research on the permeability was conducted for the purpose of determining intracellular enzyme activities *in situ* and not for the purpose of industrial applications (Felix et al., *ibid.*).

On the other hand, in recent years, genetic recombination technology has advanced drastically and excellent gene expression systems have been developed. For example, regarding yeasts, Romanos et al., *Yeast* 8: 423-488 (1992) describes various gene expression systems. In these gene expression systems, excessive enzymes are produced and accumulated in cells, so that the cells themselves can be an effective catalyst.

Furthermore, for example, if enzymes present in cell cortices, periplasms or cell membranes, such as lipase which is retained in cell cortices, are used without any treatments or if these enzymes have been expressed by gene manipulation, the cells themselves can be an effective catalyst.

However, in order to utilize the enzymes accumulated in the cells or the enzymes retained in cell cortices, periplasms or cell membranes, it is necessary to lower the barriers of cell walls, cell membranes or the like as described above. However, there is no effective means for lowering the permeability barrier, so that a process of disrupting cells is required. Furthermore, because a process of strict temperature control to prevent inactivation of the enzymes, a purification process, and other processes are required, there are disadvantages that the processes are complicated and lead to high costs.

Therefore, there is a demand for technologies that eliminate disruption of cells, extraction of enzymes and purification, and provide a low-cost catalyst that can be manipulated in a very simple manner,

namely, technologies that lower the permeability barrier of cells and use cells themselves as a catalyst.

Disclosure of the Invention

The present invention is carried out to solve the above-described problems. The present invention is directed to a cell treated with lower alcohol, wherein the reaction rate of the treated cell is at least 50 times higher than that of a cell that is not treated with lower alcohol.

In a preferable embodiment, the cell is yeast or filamentous fungus, and the cell is immobilized onto a carrier.

Furthermore, in a preferable embodiment, the lower alcohol is selected from the group consisting of methanol, ethanol, propanol, and isopropanol.

In a preferable embodiment, the cell is dried.

In a preferable embodiment, the cell contains an enzyme having a resistance to treatment with lower alcohol.

In a preferable embodiment, the enzyme is glyoxalase I or lipase.

In a preferable embodiment, the enzyme is produced by the expression of a recombinant gene.

In another aspect, the present invention is directed to a catalyst comprising a cell treated with lower alcohol, wherein the reaction rate of the catalyst is at least 50 times higher than that of a catalyst comprising a cell that is not treated with lower alcohol.

In a preferable embodiment, the cell is yeast or filamentous fungus.

In another aspect, the present invention is directed to a method for increasing the reaction rate of a cell to at least 50 times

higher than that of an untreated cell, comprising treating the cell with lower alcohol.

In a preferable embodiment, the cell is yeast or filamentous fungus.

In another aspect, the present invention is directed to a method for producing a desired substance by reacting a cell with a substrate, comprising reacting a cell treated with lower alcohol with the substrate to an enzyme, wherein the reaction rate of the cell treated with lower alcohol is at least 50 times higher than that of an untreated cell.

In a preferable embodiment, the cell is yeast or filamentous fungus, and preferably the cell is immobilized onto a carrier.

In a preferable embodiment, the cell contains an enzyme having a resistance to treatment with lower alcohol.

In a preferable embodiment, the enzyme is glyoxalase I, and the desired substance is S-lactoylglutathione.

In a preferable embodiment, the enzyme is lipase and the desired substance is fatty acid ester.

In a preferable embodiment, the glyoxalase I or the lipase is produced by the expression of a recombinant gene.

In a preferable embodiment, the cell is immobilized onto a carrier and filled in a column.

In another aspect, the present invention is directed to a sensor having a cell treated with lower alcohol, wherein the reaction rate of the treated cell is at least 50 times higher than that of a cell that is not treated with lower alcohol.

In a preferable embodiment, the cell is yeast or filamentous fungus.

The present invention solves the above-described problems.

More specifically, by treating cells with lower alcohol, the reaction rate of the cells becomes at least 50 times higher than that of untreated cells, and 200 to 600 times higher in preferable cases. This seems to be a result that the treatment with lower alcohol has lowered the permeability barrier of the cell walls or the cell membranes. In the present invention, free cells treated with lower alcohol can be used as a catalyst without any further treatment. Immobilized cells also can be treated with lower alcohol to be used as a catalyst without any further treatment. The cells or the immobilized cells treated with lower alcohol are further dried for use. Thus, the present invention provides cells having an excellent catalyst activity that can be produced by a very simple method and can be used repeatedly.

Furthermore, the present invention provides a method for producing a desired substance using the cells treated with lower alcohol as a catalyst.

Brief Description of Drawings

Figures 1a to 1c are graphs showing that yeasts treated with lower alcohol can be recycled.

Best Mode for Carrying Out the Invention

In the present invention, the term "cells" includes Gram-negative bacteria such as *E. coli*, Gram-positive bacteria such as *Bacillus subtilis*, eukaryocyte such as filamentous fungi and yeasts, animal cells, plant cells and the like. In particular, as a host for genetic recombination, *E. coli* that can be used for production of substances, and yeast (for example, yeast belonging to the *Saccharomyces* genus (*Saccharomyces cerevisiae*), yeast belonging to the *Candida* genus (*Candida antractica*, *Candida rugosa*, and *Candida*

cyindracea)) are used preferably, but are not limited to these examples. Furthermore, filamentous fungi belonging to the *Rhizomucor* genus, the *Mucor* genus, the *Aspergillus* genus, the *Rizopus* genus or the *Penicillium* genus can also be used preferably.

In the present invention, preferable examples of the lower alcohol used for treatment of cells include water-soluble alcohols having the carbon number of 1 to 11. Further, the alcohols can be monovalent, bivalent, or trivalent, and primary alcohols such as methanol and ethanol, secondary alcohols such as isopropanol, and tertiary alcohols such as t-butanol also can be used. Preferably, methanol, ethanol, or isopropanol can be used. The alcohols can be used alone or in combination of two or more.

The concentration of alcohol to treat cells is about 10% to about 100%, preferably about 20% to about 100%, more preferably about 40% to about 80%, and most preferably about 40% to about 60%, although the concentration depends on the alcohol used. When the concentration of alcohol is referred to, V/V% is used.

There is no particular limitation regarding the period of time for alcohol treatment, as long as it is at least 5 minutes. At least 10 minutes is preferable. The treatment period can be changed with the type of alcohol. Although depending on the enzyme, even if a treatment is performed with methanol or ethanol for a long period of time, this hardly affects the enzyme activities, whereas a treatment with isopropanol for a long time tends to reduce the enzyme activities slightly.

There is no particular limitation regarding the temperature of the alcohol treatment, as long as desired enzymes are not inactivated. Therefore, when the enzyme is susceptible to heat, the treatment may be performed at a low temperature. For a heat-resistant enzyme, for

example, lipase, the treatment can be performed at a high temperature. For superthermophilic archaebacteria, the temperature can be as high as 100°C or more. In general, the temperature is 4°C to 40°C.

In the present invention, "enzymes having a resistance to treatment with lower alcohol" refer to enzymes that are not inactivated (the activities are not lost) by treatment with methanol, ethanol or propanol. Examples of such enzymes include glyoxalase I, lipase, and phospholipase.

In the present invention, the reaction rate can be measured, for example, by using a suitable measuring system, such as measuring the amount of a product or a substrate that has been reduced for a predetermined period of time. The reaction rate referred to in the present invention corresponds to the initial velocity referred to in enzymology.

In the present invention, although cells that have been treated with lower alcohol may die in many cases, intracellular enzymes are resistant to treatment with lower alcohol and therefore are not inactivated with treatment with lower alcohol. In addition, the permeability barriers of cell walls or cell membranes are lowered, so that the cells themselves can be utilized as a catalyst repeatedly. The reaction rate becomes at least 50 times higher, and generally about 100 times higher. When cells are treated under preferable conditions, for example, with about 40% to about 60% of lower alcohol, the activity becomes 300 to 600 times higher.

In view of recycling the cells as a catalyst, it is preferable that the cells are immobilized onto a carrier. It is preferable that the cells are treated after being immobilized, and the cells may be dried, if necessary. Drying can be performed by any method that does not inactivate the cells, such as vacuum drying and lyophilization.

Immobilization of cells can be performed by any known method such as carrier binding, cross-linking and entrapment. Among these, carrier binding is most preferable in view of handling. Carrier binding includes chemical adsorption by which the cells are adsorbed to ion-exchange resin, or physical adsorption. In the present invention, physical adsorption using a porous carrier is most preferable. No special means is required for physical adsorption. Cells and a carrier (for example, a porous body or a foam body) are simply mixed and cultured, so that the cells enter the openings of the carrier and adhere thereto. Thus, immobilized cells can be obtained.

In the present invention, "carrier" refers to a substance that can immobilize cells, and preferably a substance that is insoluble in water or a specific solvent. As a material for the carrier used in the present invention, foam bodies or resins, for example, polyvinyl alcohol, polyurethane foam, polystyrene foam, polyacrylamide, polyvinyl formal resin porous body, silicone foam and cellulose porous body, are preferable. A suitable size of openings of the porous bodies or the foam bodies is such that the cells can enter the openings sufficiently and be grown therein, although the size depends on the cells to be immobilized. For bacteria such as *E. coli* or *Bacillus subtilis*, about 10 μ m to about 500 μ m are preferable. For filamentous fungus, yeast, eumycetes and plant cells, 50 μ m to 1,000 μ m are preferable. For animal cells, 30 μ m to 250 μ m are preferable. However, these sizes are only illustrative and do not limit the present invention.

Furthermore, the shape of the carrier can be any shape. In view of the strength of the carrier, the culturing efficiency or the like, spherical or cubical shapes are preferable, and a preferable size is 2 mm to 50 mm in diameter for spherical carriers and 2 mm to 50 mm in length of the side for cubical carriers.

As described above, cell bodies are immobilized in a carrier simply by mixing the cell bodies and the carrier, and can be treated with lower alcohol without any further process.

The thus obtained immobilized cells are used for reaction in a suspension, or can be filled in a column or the like and used as a so-called bioreactor. The cells can be reacted repeatedly in a continuous or batch manner.

The cells (catalyst) of the present invention can be used, not only for production of proteins (enzymes, antibodies, etc.) and amino acids used for pharmaceuticals, foods etc., but also for removal of environmental pollutants. Furthermore, the cells of the present invention also can be used for resolution of optically active substances.

In the present invention, enzymes having a resistance to organic solvent may have been expressed by genetic recombination. It is known to those skilled in the art to introduce a desired gene into a cell to express a desired enzyme (protein). "Introduction of a desired gene" means that a gene is introduced into a cell and expressed. Any method can be used for this operation. This means that, in bacteria, yeast, filamentous fungus, eumycetes, plant or animal cells, a transformant is expressed by inserting the desired gene in the form of plasmid, or by inserting it to a gene of a host, or by effecting homologous recombination with a gene of a host by using transformation, transduction, transfection, cotransfection, electroporation, etc.

The obtained recombinant cell can accumulate a large amount of a desired enzyme (protein) within the cell bodies. Therefore, when the barrier of cell walls or cell membranes is lowered by the method of the present invention so that a substrate is allowed to permeate easily, the substrate is in more contact with the enzyme so that the effect of

accelerating the enzyme reaction can be obtained.

The cells or the catalyst of the present invention can be used as a sensor as well. For example, BOD can be measured with oxidation-reduction enzymes in cells. The sensor includes a transducer such as an oxygen electrode and a hydrogen peroxide electrode. The transducer can be determined in view of an enzyme (catalyst) to be used and a substance to be measured. The biosensor of the present invention has the advantages that the permeability of a substrate is good because the permeability barrier is lowered, the sensitivity is high and this biosensor can be used repeatedly.

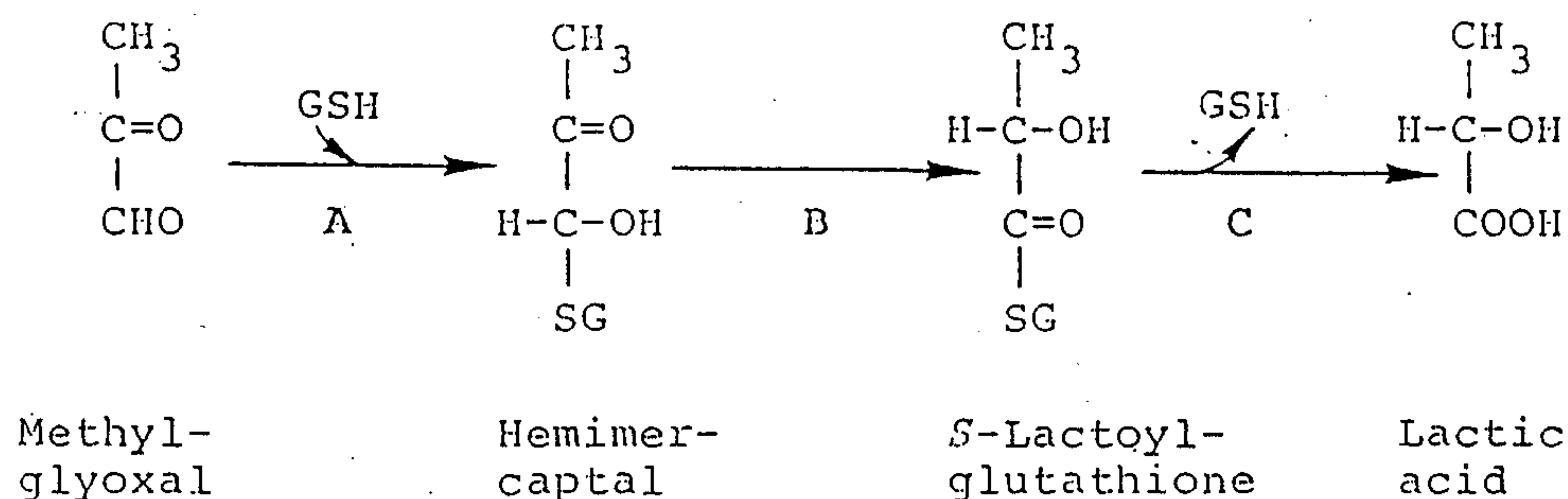
When the cells used in the present invention produce lipase, the cells are treated with lower alcohol, and these treated cells can be used as a catalyst for transesterification. Namely, as known to those skilled in the art, when glycerol ester of fatty acid (e.g., triester) is used as a substrate, and the substrate is reacted with lower alcohol treated cells in the presence of lower alcohol, a fatty acid ester can be obtained. Fatty acid ester is useful as biodiesel fuel.

(Examples)

Hereinafter, the present invention will be described by taking the following as examples: a process for producing S-lactoylglutathione (which may be referred to as S-LG) from methylglyoxal, using yeast, *Saccharomyces cerevisiae* as a cell and glyoxalase I as an enzyme that is resistant to treatment with lower alcohol; and production of a fatty acid ester, using filamentous fungus, *Rhizopus oryzae* as a cell and lipase as an enzyme, although the present invention is not limited to these examples.

Glyoxalase I catalyzes a reaction from hemimercaptal to S-LG (step B) in the reaction path for producing lactic acid from

methylglyoxal, as described below. GSH stands for glutathione.



Step A, nonenzymatic; step B, glyoxalase I; step C, glyoxalase II. GSH, glutathione.

S-LG, which is a reaction product, is a compound having several physiological functions (Gillespie et al., Nature 227: 135-136 (1975); Kosugi et al., Appl. Microbiol. Biotechnol. 28: 263-267 (1988); and Thornalley et al., Biochem. Biophys. Res. Commun. 145:769-774 (1979)). There is a demand for mass production of S-LG for analysis of its physiological functions and applications.

(Yeast Preparation Example: Preparation of yeast that overexpresses glyoxalase I)

Plasmid pE24GLO1 having a glyoxalase I gene was donated by Professor Akira Kimura of Research Institute for Food Science, Kyoto University. This plasmid pE24GLO1 is a plasmid in which 2500bp fragment including an open reading frame of glyoxalase I gene (GLO1 gene) is incorporated into a multicopy plasmid Yep24 (Ura3), as described by Inoue and Kimura et al., J. Biol. Chem. 271: 25958-25965 (1996). This plasmid pE24GLO1 was introduced to yeast, *Saccharomyces cerevisiae* YPH250 (trp^- , leu^- , lys^- , ade^- , ura3-52), using a lithium acetate method. A transformant was obtained as a strain that grows in agar medium containing SD minimal medium

(glucose (20g/l), Difco yeast nitrogen base w/o amino acids (6.7g/l)) containing trp, Leu, Lys, and ade in amounts of 40, 60, 30, and 40 $\mu\text{g/ml}$, respectively.

The obtained transformant was cultured in SD liquid medium having the above-described composition at 30°C for 16 hours, and a cell extract was obtained by cell extraction method as described below. Then, the activity of glyoxalase I was measured. This transformant (recombinant yeast) accumulated a large amount of glyoxalase I in the cell body, compared with a nontransformant.

The activity of glyoxalase I was determined in the following manner. The cell extract or the treated yeast was suspended in 100mM phosphate buffer (pH 6.0) containing 50mM methylglyoxal and 50mM glutathione and was shaken at 30°C. A predetermined period of time later, an absorbance at 240nm was measured and an amount of S-LG produced was measured with a molar extinction coefficient of $3300\text{cm}^{-1}\text{M}^{-1}$. The production amount ($\mu\text{mol/min/g}$ -wet yeast) per unit time and per unit wet yeast weight was defined as the reaction rate.

(Example 1 and Comparative Example 1)

(Treatment of yeast with lower alcohols and organic solvents)

The yeast obtained in the above-described manner was precultured in SD minimal medium at 30°C for 16 hours and then inoculated in fresh SD medium to further culture at 30°C, and the culturing was stopped when OD_{610} of the culture reached 1.0. Yeast cell bodies were collected by centrifugation at 5,000rpm for 5 minutes. The collected cell pellets were washed with 0.85% NaCl and used for treatments with organic solvents.

Each of methanol, ethanol and isopropanol with various concentrations as lower alcohol, and acetone, ethyl acetate and diethyl

ether as comparative organic solvents in an amount of 1.0ml is added to the pellets of the yeast in a wet weight of 0.1g to suspend the yeast for treatment with organic solvent at 4°C or 25°C for a predetermined period of time. After the treatment, treated yeast cell bodies were collected by centrifugation at 5,000rpm for 5 minutes. The collected cell pellets were washed with 0.85% NaCl and used as an enzyme (catalyst).

In comparison, 1 ml of 350mM potassium phosphate buffer at pH 7.0 containing 1% Triton X-100 or 80mM hexamethylene diamine (HMDA) was added to the pellets of the yeast in a wet weight of 0.1g to effect a reaction at 4°C for 10 minutes. After the treatment, the treated yeast cell bodies were collected by centrifugation at 5,000rpm for 5 minutes. The collected cell pellets were washed with 0.85% NaCl and used as an enzyme (catalyst).

Further in comparison, the recombinant yeast obtained by culturing and washing was resuspended in 100mM potassium phosphate buffer at pH 7.0. Yeast cells were disrupted by adding glass beads thereto and by performing 15 cycles of vortexing for 30 seconds and cooling on ice for 1 minute. Then, cell homogenate was centrifuged at 10,000g for 20 minutes at 4°C, and a resultant supernatant was used as a cell extract.

Furthermore, a cell extract was prepared by ethyl acetate extraction method based on the method of Inoue et al., Appl. Microbiol. Biotechnol. 36: 469-472 (1992). More specifically, 0.1g (wet weight) of the recombinant yeast obtained by culturing and washing as described above was resuspended in 2 ml of 100mM potassium phosphate buffer at pH 7.0, and 2 ml of ethyl acetate was added thereto, followed by incubation at 30°C for 10 hours and centrifugation at 5,000rpm for 5 minutes at 4°C. The thus obtained water phase was used as a cell

extract.

(Production of S-LG by using the treated yeast)

The obtained treated yeast in an amount of 0.1 g (wet weight) or an extract from the same amount of cells was suspended in 100mM phosphate buffer (pH 6.0) containing 50mM methylglyoxal and 50mM glutathione (GSH) and was shaken at 30°C. Then, the amount of S-LG produced was measured by the above-described method, and the initial velocity in the production was obtained. Table 1 shows the results of treatments with various concentrations of lower alcohols for various periods of time at 25°C. In Table 1, ND stands for “not done”.

Table 1

Concentration of organic solvent (%)	Treatment time (min)	Production rate of S-lactoylglutathione (μmol/min/g-wet weight)					
		methanol	ethanol	isopropanol	acetone	ethyl acetate	diethyl ether
0	0	1.1	1.1	1.1	1.1	1.1	1.1
20	120	ND	18	280			
	240	18	30	380			
40	10	280	400	550			
	120	280	368	280			
	240	260	340	180			
60	10	300	296	296			
	120	280	188	188			
	240	280	160	128			
100	10	220	360	398	304	377	337
	120	120	360	420	ND	ND	ND
	240	100	280	360	ND	ND	ND

Treated at 25 °C

The results of Table 1 show that the lower alcohol treatment drastically increases the reactivity (initial velocity) of the cells by a factor of 200 to 550 (i.e., the permeability barrier of cells was made

smaller and the reaction was accelerated), the effects of treating the cells are varied with the type of lower alcohols, and the initial velocity becomes at least 200 times even if alcohol having a concentration of 40% or more is used and the treatment is performed for 10 minutes. The results also show that among lower alcohols, isopropanol can lower the permeability barrier at a relatively lower concentration than methanol and ethanol. There is the tendency that shorter treatment times are better for all the alcohols.

The treatment with diethyl ether, ethyl acetate, or acetone can increase the reactivity of yeast as well as the lower alcohols. However, there is a problem in that a large amount of protein leaks from the cells.

Next, Table 2 shows the results of treating the cells at 4°C with various concentrations of lower alcohols for various periods of time.

Table 2

Concentration of organic solvent (%)	Treatment time (min)	Production rate of S-lactoylglutathione ($\mu\text{mol}/\text{min}/\text{g-wet weight}$)						
		methanol	ethanol	isopropanol	1%Triton X-100	80mM HMDA	Cell extract	Cell extract with ethyl acetate
0	0	1.1	1.1	1.1	10	15	109	260
20	120	ND	ND	10				
	240	ND	ND	10				
40	10	180	400	640				
	120	180	340	500				
	240	160	320	300				
60	10	340	300	300				
	120	302	387	300				
100	10	390	428	460				
	120	345	326	340				

Treated at 4°C

The results show that although the effects of the treatment at 4°C are substantially the same as those at 25°C, it is preferable to treat the cells at a lower temperature as the concentration of alcohol is higher, and the treatment at 4°C has higher effects than at 25°C.

Furthermore, in the treatment with Triton X-100 and the treatment with 80mM hexamethylene diamine (HMDA), the initial velocity was increased by a factor of 10 to 15, and the treatment with lower alcohols exhibited far larger effects (at least a factor of at least 200).

Furthermore, a liquid obtained by disrupting the yeast with glass beads and extracting, and enzymes extracted with ethyl acetate showed the initial velocity in the reaction of 109 times and 260 times the initial velocity of untreated yeast, respectively. However, the lower alcohol treated yeast of the present invention can be prepared far more easily than these enzyme extracts, and has higher reaction rate. Moreover, the present invention has an advantage in that it can be recycled as shown in Example 2 below.

(Example 2)

The yeast cell bodies treated with 40% methanol, ethanol, and propanol at 4°C for 10 minutes that were used in Example 1 were used again to measure the amount of S-LG produced. The results are shown in Figure 1. Figure 1a shows the case where yeast was treated with 40% methanol, Figure 1b shows the case where yeast was treated with 40% ethanol, and Figure 1c shows the case where yeast was treated with 40% propanol. ○ shows the second use, ▲ shows the third use, and ◇ shows the fourth use. These results show that although the activity is slightly reduced, recycling is possible. These results also suggest that enzymes are retained in the yeast cells

treated with lower alcohols, and there is little leakage of enzymes from the cells during catalytic reaction.

(Example 3)

First, 100 pieces of polyurethane foams (BSPs) with 6mm cube as a carrier for immobilization were placed in a shaker flask including 100ml of lipase production medium (containing 70g of polypeptone, 1.0g of KH_2PO_4 , 1.0g of NaNO_3 , 0.5g of $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ and 20g of oleic acid in 1L), and *Rhizopus oryzae* IFO 4697 was inoculated thereto and cultured at 30°C for 4 days. The cell bodies were immobilized onto the BSPs during culturing. When the culturing was completed, the BSPs to which the cell bodies were immobilized were collected, and treated with 80% alcohol at 25°C for 10 minutes. A mixture of soybean oil and methanol in a molar ratio of 1:1 was added thereto, and by utilizing lipase in the treated cell bodies, a reaction for synthesis of fatty acid ester was performed with shaking at 130 times/min at 30°C for 2 days. The amount of the obtained fatty acid ester was determined by gas chromatography with tricaprilin as the internal standard, using a DB-5 capillary column. In comparison, BSPs-cell bodies treated with acetone were used, and untreated BSPs-cell bodies were used as control. The results are shown in Table 3.

Table 3

Treatment	Conversion rate (%)
Methanol	9.6
Ethanol	10.0
Isopropanol	18.0
Acetone	3.8
Untreated	0.1

The results show that the treatment with alcohol, especially the treatment with isopropanol, has a large effect on filamentous fungus as well, and untreated cells have substantially no activity.

Industrial Applicability

The cells treated with lower alcohol of the present invention can be used as a catalyst that can be manipulated in a simple manner, has a higher activity by a factor of several hundreds than that of untreated cells, and can be recycled. More specifically, by merely treating cells with lower alcohol, the reaction rate of an enzyme having a resistance to organic solvent in the cells can reach 600 times higher than that of cells untreated with lower alcohol. The enzyme activity retained inside the cells, cell cortex, periplasm or the like is expected to increase significantly by lowering the permeability barrier of cell membranes, cell walls or the like.

CLAIMS

1. A cell treated with lower alcohol, wherein the reaction rate of the treated cell is at least 50 times higher than that of a cell that is not treated with the lower alcohol.
2. The cell of claim 1, wherein the cell is yeast or filamentous fungus.
3. The cell of claim 1 or 2, wherein the cell is immobilized onto a carrier.
4. The cell of any one of claims 1 to 3, wherein the lower alcohol is selected from the group consisting of methanol, ethanol, propanol and isopropanol.
5. The cell of any one of claims 1 to 4, wherein the cell is dried.
6. The cell of any one of claims 1 to 5, wherein the cell contains an enzyme having a resistance to treatment with lower alcohol.
7. The cell of claim 6, wherein the enzyme is glyoxalase I or lipase.
8. The cell of claim 6 or 7, wherein the enzyme is produced by the expression of a recombinant gene.
9. A catalyst comprising a cell treated with lower alcohol, wherein the reaction rate of the catalyst is at least 50 times higher than that of a catalyst comprising a cell that is not treated with lower alcohol.

10. The cell of claim 9, wherein the cell is yeast or filamentous fungus.
11. A method for increasing the reaction rate of a cell to at least 50 times higher than that of a cell that is not treated with lower alcohol, comprising treating the cell with lower alcohol.
12. A method for producing a desired substance by reacting a cell with a substrate, comprising reacting a cell treated with lower alcohol with the substrate to an enzyme, wherein the reaction rate of the cell is at least 50 times higher than that of an untreated cell.
13. The method of claim 12, wherein the enzyme is glyoxalase I and the desired substance is S-lactoylglutathione.
14. The method of claim 12, wherein the enzyme is lipase and the desired substance is fatty acid ester.
15. The method of claim 13 or 14, wherein the enzyme is produced by the expression of a recombinant gene.
16. The method of any one of claims 13 to 15, wherein the cell is immobilized onto a carrier and filled in a column.

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Fig.1

