

IMMOBILIZED LIPASE AND METHOD FOR PRODUCING THE SAME

Technical Field

The present invention relates to a highly active
5 immobilized lipase suitably used for various esterification
reactions, transesterification reactions, and the like and
a method for producing the same.

Background Art

10 Modification of a fat/oil with a transesterification
reaction using a lipase as a catalyst has widely been
carried out. There have been known a batch method, a
continuous method with a column, and the like as the method
of transesterification reaction of a fat/oil. Traditionally,
15 the lipase has generally been used as an immobilized lipase
obtained by immobilizing the lipase to a certain carrier.
For the lipase immobilization, an anion exchange resin
(Patent Document 1), a phenol formaldehyde absorbing resin
(Patent Document 2), a hydrophobic porous carrier (Patent
20 Document 3), a cation exchange resin (Patent Document 4), a
chelate resin (Patent Document 5), and the like have been
used, but the methods disclosed in these Documents have the
drawback of a reduction in transesterification activity due
to the immobilization of the lipase to the carrier as well
25 as the tendency that the cost is increased due to the

expensive carrier. Also, as a method for enhancing activity during immobilization, addition of a polyhydroxy compound that does not have emulsification activity (Patent Document 6) and addition of a fatty acid derivative (Patent Document 7) have been proposed, but these methods are not satisfactory yet.

Patent Document 1: JP 60-98984 A

Patent Document 2: JP 61-202688 A

10 Patent Document 3: JP 2-138986 A

Patent Document 4: JP 3-61485 A

Patent Document 5: JP 1-262795 A

Patent Document 6: JP 7-265073 A

Patent Document 7: JP 62-134090 A

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Disclosure of Invention

Problems to be Solved by the Invention

An object of the present invention is to provide an immobilized lipase, transesterification activity of which is improved as compared to conventional methods.

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Means for Solving the Problems

The present inventors have intensively studied to solve the above problems and, as a result, have found that an immobilized lipase obtained by immobilizing an oil-in-

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water emulsion containing a fat/oil, a polymer emulsifier, and an enzyme having lipase activity to a carrier is prominently improved in transesterification activity. The present invention has been completed on the basis of this finding.

That is, the present invention relates to:

- (1) an immobilized lipase, comprising an oil-in-water emulsion containing a fat/oil, a polymer emulsifier and an enzyme having lipase activity, wherein the oil-in-water emulsion is immobilized to a carrier;
- (2) the immobilized lipase according to (1), wherein the polymer emulsifier is a polysaccharide;
- (3) the immobilized lipase according to (1), wherein the polymer emulsifier is a water-soluble soybean polysaccharide;
- (4) a method for producing an immobilized lipase, comprising: preparing an oil-in-water emulsion containing a fat/oil, a polymer emulsifier, and an enzyme having lipase activity; absorbing the oil-in-water emulsion to a carrier, followed by drying; and
- (5) a method for improving a transesterification activity of an immobilized lipase, comprising: preparing an oil-in-water emulsion containing a fat/oil, a polymer emulsifier, and an enzyme having lipase activity; absorbing the oil-in-water emulsion to a carrier, followed by drying.

Effect of the Invention

According to the present invention, since transesterification activity of immobilized lipase can be improved, it is possible to increase a transesterification reaction amount per unit of enzyme weight as well as to improve productivity of transesterified oil.

Best Mode for Carrying out the Invention

Hereinafter, the present invention will be described specifically. A polymer emulsifier to be used in the present invention is a polymer having emulsifying capability and is preferably a natural polymer emulsifier, and examples thereof include animal-derived protein, plant-derived protein, emulsifying polysaccharide, and the like. More specifically, the animal-derived protein includes protein material such as skimmed milk powder and whole milk powder derived from various animals; protein such as casein, lacto-albumin, and gelatin obtained by fractionating and purifying of the protein material; hydrolysate thereof; and the like. The plant-derived protein includes protein material such as isolated protein derived from beans such as soybean, pea, red bean, and broad bean; protein such as glycinin, β -conglycinin, and phaseolin obtained by fractionating the protein material; hydrolysate thereof;

and the like. The emulsifying polysaccharide includes various polysaccharides having emulsifying activity, such as water-soluble soybean polysaccharide, gum arabic, and various modified starches, and the like. Among the above, it is preferable to use the emulsifying polysaccharide, particularly the water-soluble soybean polysaccharide, as the emulsifier because transesterification activity is strongly maintained. In the present invention, the above-described polymer emulsifier is the essential component, but it is also possible to use a low molecular emulsifier in combination with the polymer emulsifier.

As a fat/oil to be used for preparation of an oil-in-water emulsion, it is possible to use animal and plant fat/oils such as soybean oil, coconut oil, palm oil, palm kernel oil, rapeseed oil, sunflower oil, peanut oil, olive oil, rice oil, shea butter, sal fat, cotton seed oil, cacao butter, olive oil, sesame seed oil, wheat germ oil, illipe butter, safflower oil, corn oil, milk fat, mutton fat, goat fat, horse fat, egg yolk oil, sardine oil, whale oil; triglycerides including fractionated or hydrogenated substances of the above-listed animal and plant fat/oils; lower alcohol ester of fatty acid; glycerin fatty acid monoester, glycerin fatty acid diester, or the like; or combination thereof.

In the preparation of the oil-in-water emulsion, an

amount of the polymer emulsifier with respect to the fat/oil is not particularly limited insofar as stable emulsification is performed. If a desirable range is set, the amount of the polymer emulsifier to be mixed with the fat/oil is preferably 0.1 to 50 wt%, more preferably 1 to 40 wt%, most preferably 5 to 30 wt%. When the ratio between the polymer emulsifier and the fat/oil is within the above-specified range, a stable oil-in-water emulsion is obtained, thereby giving high transesterification activity after immobilization.

A mixture liquid containing the polymer emulsifier and the fat/oil is formed into the oil-in-water emulsion with an appropriate emulsifying treatment. The emulsification can be carried out by using a homogenizer, Homomixer, Nanomizer, or the like at appropriate pressure or by using membrane emulsification or ultrasonic wave. An average particle diameter of the oil-in-water emulsion to be used is preferably 10 μm or less, and more preferably 3 μm or less. In addition, since preparation the oil-in-water emulsion having an average particle diameter of 0.5 μm or less makes poor industrial production efficiency, the use of the oil-in-water emulsion having particle diameter larger than 0.5 μm is the common practice.

As a lipase to be used in the present invention, those of wide range of origins derived from bacteria, yeasts,

filamentous bacteria, actinomycetes, and the like can be used without particular limitation, and specific example thereof includes genus *Rhizopus* (*Rhizopus* sp.), genus *Aspergillus* (*Aspergillus* sp.), genus *Candida* (*Candida* sp.),
5 genus *Mucor* (*Mucor* sp.), genus *Pseudomonas* (*Pseudomonas* sp.), genus *Alcaligenes* (*Alcaligenes* sp.), genus *Arthrobacter* (*Arthrobacter* sp.), genus *Staphylococcus* (*Staphylococcus* sp.), genus *Penicillium* (*Penicillium* sp.), genus *Geotrichum* (*Geotrichum* sp.), and the like. Also, animal-derived and
10 plant-derived lipase such as pancreatic lipase and rice bran lipase can be used. A crude enzyme or purified enzyme of any of these lipases is mixed as an enzyme having lipase activity with the oil-in-water emulsion that has been prepared in advance. Alternatively, the oil-in-water
15 emulsion can also be obtained by subjecting a mixture liquid containing the polymer emulsifier, the fat/oil, and the lipase to an emulsifying treatment. The use of the lipase having high heat resistance allows the use of the oil-in-water emulsion containing a high melting point
20 fat/oil, thereby an immobilized enzyme highly resistant to flavor deterioration caused by oxidation or hydrolysis of fat/oil can be obtained.

A mixing ratio between the enzyme and the emulsion can be varied as a ratio of the fat/oil component in the
25 emulsion to the lipase activity of the enzyme. More

specifically, a ratio of the fat/oil component amount (mg) with respect to lipase activity (Unit) measured in accordance with "JIS K0601: Industrial Lipase Activity Measurement Method" is preferably 0.06 or more, more preferably 0.4 or more. Also, the ratio is preferably 10 or less, and more preferably 3 or less. When the ratio is less than 0.06, the effect is not sufficiently exhibited in some cases. When the ratio is larger than 10, the activity per unit weight of the immobilized lipase to be prepared is decreased, and the amount of the immobilized lipase to be added to the reaction system is increased, and the reaction system is enlarged, or a moisture content derived from the carrier is increased, thereby easily causing a side reaction. The mixing of the enzyme with the emulsion can be carried out by adding the enzyme in the form of a liquid to the oil-in-water emulsion followed by homogenizing or by adding the enzyme in the form of solid or powder into the oil-in-water emulsion followed by dissolving or dispersing. Alternatively, the oil-in-water emulsion can also be obtained by subjecting the mixture liquid containing the polymer emulsifier, the fat/oil, and the enzyme to an emulsifying treatment.

The carrier to be used in the present invention includes kieselguhr, alumina, Celite, cellulose and cellulose derivatives, porous glass, glass fiber, silicic

acid gel, florisil, ion exchange resin, titanium dioxide, kaolinite, pearlite, and the like, but an ingredient of the carrier is not particularly limited insofar as the carrier has the function of capturing lipase molecules.

5 Preparation of the immobilized lipase is carried out by contacting the oil-in-water emulsion containing above-described lipase with above-described carrier, followed by drying, thereby the lipase is absorbed to the carrier. For contacting, the carrier can be soaked into the oil-in-water
10 emulsion containing the lipase, or the emulsion can be sprayed to the carrier. In the case of contacting the oil-in-water emulsion to the carrier, a moisture content that can be absorbed by the carrier is preferred. When the contact is carried out in the moisture content larger than
15 the absorbable amount, it is difficult for the carrier to carry the predetermined enzyme amount due to leakage of the oil-in-water emulsion from the carrier.

 The carrier which is absorbing the lipase can be dried by various drying methods. More specifically, the drying
20 method includes drying means by reducing a pressure; so-called through-flow drying in which the carrier is brought into contact with a relatively low humidity air, nitrogen, or another inert gas, and the like.

 In particular, drying under reduced pressure, in which
25 the carrier to which the lipase is absorbed is retained

under a pressure environment that is lower than a water vapor pressure at a certain temperature, is preferred.

Since the immobilized lipase prepared as described above has high transesterification activity, the
5 immobilized lipase is suitably used for modification of fat/oil and the like. An embodiment of the immobilized lipase includes the use in various methods such as batch method and continuous method using a column.

10 Examples

Examples will be described in the following, however the technical scope of the present invention is not limited to them.

(Example 1)

15 An oil-in-water emulsion A was prepared by: dispersing and dissolving 8 g of water-soluble soybean polysaccharide into 60 g of water; adding 32g of purified palm oil to the solution; preliminary emulsifying with a Homomixer (manufactured by Tokushu Kika Kogyo Co., Ltd); and
20 emulsifying by passing the preliminary emulsion through a high pressure laboratory homogenizer (manufactured by Ranni a/s) twice at 150 kg/cm². The obtained emulsion had an average particle diameter of 1.8 μ m. A hydrate was obtained by dispersing 7 g of commercially available lipase
25 powder manufactured by Amano Enzyme Inc. (originating from

Penicillium; hydrolysis activity: 1,000 unit/g) into 10 g of cold water; mixing the dispersion with 35 g of the oil-in-water emulsion A; and spraying the mixture onto 50 g of kieselguhr. The kieselguhr was freeze-dried to obtain an immobilized lipase 1 having a moisture content of 3 wt%.

Transesterification activity was determined by adding 10 g of the immobilized lipase 1 to 100 g of a substrate (substrate moisture content: < 0.1%) obtained by blending a palm middle melting point fraction and a palm low melting point fraction at a ratio of 6:4, and then activating at 60°C. In an evaluation of a reaction product, tripalmitin content was measured with a gas chromatography (GC), and reaction rate was calculated by the following formula.

* Reaction rate = (tripalmitin content of reaction product - tripalmitin content of starting fat or oil) / (tripalmitin content of composition in reaction equilibrium state - tripalmitin content of starting fat or oil)

Next, an initial reaction velocity constant k was calculated by the following formula.

* Initial reaction velocity constant $k = \ln[1/(1 - \text{reaction rate after 24 hours reaction})]$

A value calculated from the reaction velocity constant k and the amount of the lipase (amount of enzyme preparation having lipase activity contained in immobilized lipase) added to the starting fat/oil with the following

formula was used as a transesterification activity value, and the value is shown in Table 1.

* Transesterification activity value = $k \times$ (amount of starting fat or oil/amount of enzyme preparation having lipase activity)

(Example 2)

A hydrate was obtained by dispersing 7 g of commercially available lipase powder manufactured by Amano Enzyme Inc. (same as above) into 10 g of cold water; mixing the dispersion with 17.5 g of the oil-in-water emulsion A; and dispersing 50 g of kieselguhr into the mixture. After that, preparation and evaluation of immobilized lipase were carried out in the same manner as in Example 1.

(Example 3)

Preparation and evaluation of immobilized lipase were carried out in the same manner as in Example 2, except that the added amounts of glucose and the oil-in-water emulsion A were 13.3 g and 1.75 g respectively.

(Example 4)

Preparation and evaluation of immobilized lipase were carried out in the same manner as in Example 2, except that the added amounts of glucose and the oil-in-water emulsion A were 13.7 g and 0.88 g respectively.

(Example 5)

An oil-in-water emulsion B was prepared according to

the preparation method in Example 1, except that the pressure of the high pressure laboratory homogenizer was 50 kg/cm². The obtained emulsion had an average particle diameter of 4.8 μ m. Preparation and evaluation of immobilized lipase were carried out in the same manner as in Example 1 except for using the oil-in-water emulsion B. (Example 6)

An oil-in-water emulsion C was prepared according to the preparation method in Example 1, except that a gum arabic was used in place of the water-soluble soybean polysaccharide. The obtained emulsion had an average particle diameter of 2 μ m. Preparation and evaluation of immobilized lipase were carried out in the same manner as in Example 1 except for using the oil-in-water emulsion C. (Example 7)

An oil-in-water emulsion D was prepared according to the preparation method in Example 1, except that commercially available casein sodium (EMLV: manufactured by DMV) was used in place of the water-soluble soybean polysaccharide. The obtained emulsion had an average particle diameter of 2.2 μ m. Preparation and evaluation of immobilized lipase were carried out in the same manner as in Example 1 except for using the oil-in-water emulsion D. (Example 8)

An oil-in-water emulsion E was prepared according to

the preparation method in Example 1, except that an isolated soybean protein (Fujipuro R: manufactured by Fuji Oil Co., Ltd.) was used in place of the water-soluble soybean polysaccharide. The obtained emulsion had an average particle diameter of 3.5 μm . Preparation and evaluation of immobilized lipase were carried out in the same manner as in Example 1 except for using the oil-in-water emulsion E.

(Comparative Example 1)

An oil-in-water emulsion F was prepared according to the preparation method in Example 1, except that commercially available sucrose fatty acid ester (DK-SS: manufactured by Dai-ichi Kogyo Seiyaku Co., Ltd.) was used in place of the water-soluble soybean polysaccharide. The obtained emulsion had an average particle diameter of 2.4 μm . Preparation and evaluation of immobilized lipase were carried out in the same manner as in Example 1 except for using the oil-in-water emulsion F.

(Comparative Examples 2 to 4)

Evaluations were carried out in the same manner as in Comparative Example 1 except for using sucrose fatty acid ester (DK-F-160: manufactured by Dai-ichi Kogyo Seiyaku Co., Ltd./Comparative Example 2), polyglycerin fatty acid ester (Sansoft Q14S: manufactured by Taiyo Kagaku Co., Ltd./Comparative Example 3), and polyglycerin fatty acid

ester (Sansoft Q12S: manufactured by Taiyo Kagaku Co., Ltd./Comparative Example 4) in place of the sucrose fatty acid ester (DK-SS).

(Comparative Example 5)

- 5 Preparation and evaluation of immobilized lipase were carried out in the same manner as in Example 1 except for using 14 g of glucose and 21 g of water in place of 35 g of the oil-in-water emulsion A.

(Table 1) Reactivity and Transesterification Activity after 24 hours Reaction

	Composition					Enzyme activity	
	Fat/oil (g)	Emulsifier (g)	Glucose (g)	Enzyme (g)	Fat/oil (mg)/Enzyme Units	Reaction rate (%)	Transesterification activity
Example 1	11.2	2.8	-	7.0	7,000	80	161
Example 2	5.6	1.4	7.0	↑	↑	75	139
Example 3	0.56	0.14	13.3	↑	↑	45	60.0
Example 4	0.28	0.07	13.7	↑	↑	28	33.0

(Table 2) Reactivity and Transesterification Activity after 24 hours Reaction

	Emulsifier	Composition					Emulsion state		Enzyme activity	
		Fat/oil (g)	Emulsifier (g)	Glucose (g)	Enzyme (g)	Fat/oil (mg)/Enzyme Units	Homogenizing pressure (kgf)	Emulsion particle diameter (μm)	Reaction rate (%)	Transesterification activity
Example 1	Water-soluble soybean polysaccharide	11.2	2.8	-	7.0	7,000	1.6	1.8	80	161
Example 5	↑	↑	↑	-	↑	↑	↑	4.8	70	120
Example 6	Gum arabic	↑	↑	-	↑	↑	↑	2.0	72	127
Example 7	Casein Na	↑	↑	-	↑	↑	↑	2.2	58	86.8
Example 8	Soybean protein	↑	↑	-	↑	↑	↑	3.5	63	99.4
Comparative Example 1	Sucrose ester	↑	↑	-	↑	↑	↑	2.4	45	59.8
Comparative Example 2	Sucrose ester	↑	↑	-	↑	↑	↑	1.6	41	52.8
Comparative Example 3	Polyglycerin ester	↑	↑	-	↑	↑	↑	2.2	42	54.5
Comparative Example 4	Polyglycerin ester	↑	↑	-	↑	↑	↑	3.7	39	49.4
Comparative Example 5	-	-	-	14	↑	↑	-	-	15	19.8

From the results shown in Table 1, it was confirmed that the transesterification activity was increased by adding the emulsion in an amount that the solid component (mg) of the emulsion was 0.05 times or more of the lipase activity (Unit), and that the transesterification activity can be prominently enhanced by adding the emulsion in an amount that the solid component (mg) of the emulsion was 0.1 times or more of the lipase activity (Unit), as compared to the products without adding the emulsion (Comparative Example 2). As the emulsifier, the polysaccharide having emulsifying property was particularly preferable. It was also confirmed that the effect was tend to reduce when the average particle diameter of the oil-in-water emulsion to be added was larger than 4 μm (Example 5).

CLAIMS

1. An immobilized lipase, comprising an oil-in-water emulsion containing a fat/oil, a polymer emulsifier and an enzyme having lipase activity, wherein the oil-in-water emulsion is immobilized to a carrier.

2. The immobilized lipase according to claim 1, wherein the polymer emulsifier is a polysaccharide.

3. The immobilized lipase according to claim 1, wherein the polymer emulsifier is a water-soluble soybean polysaccharide.

4. A method for producing an immobilized lipase, comprising: preparing an oil-in-water emulsion containing a fat/oil, a polymer emulsifier, and an enzyme having lipase activity; absorbing the oil-in-water emulsion to a carrier, followed by drying.

5. A method for improving a transesterification activity of an immobilized lipase, comprising: preparing an oil-in-water emulsion containing a fat/oil, a polymer emulsifier, and an enzyme having lipase activity; absorbing the oil-in-water emulsion to a carrier, followed by drying.