

Description

A METHOD FOR PREPARING HIGH-PURITY POLYETHYLENEGLYCOL ALDEHYDE DERIVATIVES

Technical Field

- [1] The present invention relates to a method for preparing high-purity polyethyleneglycol aldehyde derivatives.

Background Art

- [2] Polyethyleneglycols (PEGs) are well known as representative hydrophilic polymers capable of forming hydrogen bonds with water molecules, along with natural polymers and synthetic polymers.
- [3] They are soluble in many organic solvents and are nearly nontoxic to humans. Since PEG is completely stretched in water, it may be conjugated with various medications (proteins, peptides, enzymes, genes, etc.) to reduce the toxicity of the medication molecules via steric hindrance and to protect the activity of the medication molecules from the immune system of the human body. Therefore, it may be applied for various medicines to slow clearance from the blood.
- [4] Further, when attached to medications having good medicinal effect but being highly toxic and having low solubility, the resultant PEG-drug has improved solubility and reduced toxicity.
- [5] In order to introduce PEG to drugs, various functional groups are attached at the end of the PEG chain.
- [6] PEG-propionaldehyde is used to increase solubility and efficiency of drugs by conjugation.
- [7] PEG-propionaldehyde and methoxy PEG-propionaldehyde (mPEG-propionaldehyde) may be obtained by oxidizing the terminal hydroxyl group of PEG or introducing an acetal group followed by hydrolysis. For example, US Patent No. 6,465,694 discloses a method for preparation of PEG-aldehyde derivatives, wherein oxygen gas is added to a mixture of PEG and a catalyst to oxidize the $-CH_2OH$ group to $-CHO$. However, the PEG chain may be decomposed under most oxidation conditions. And, the introduction of an acetal group at the end of the PEG chain is commercially inapplicable because the reactants are expensive.
- [8] Further, with regard to PEGylation, or the covalent attachment of PEG to a drug, US Patent No. 4,002,531 (Pierce Chemical Company) discloses a process of oxidizing mPEG (1 K) with MnO_2 to prepare mPEG acetaldehyde and attaching it to the enzyme trypsin (PEGylation) for use as a drug delivery system. However, this oxidation reaction may result in increased decomposition of the PEG chain. In addition, the

conversion rate is not so high, with 80% or below.

- [9] In *J. Polym. Sci. Ed*, 1984, 22, pp 341-352, PEG-acetaldehyde was prepared from the reaction of PEG (3.4 K) with bromoacetaldehyde to prepare PEG-acetal, followed by hydrolysis. According to the paper, the degree of activation of aldehyde at the terminal group was about 65%, with the remaining -35% remaining as unreacted hydroxyl groups. Thus, it may be inapplicable to a drug delivery system without further purification.
- [10] In US Patent No. 4,002,531 (The University of Alabama in Huntsville), the hydroxyl group at the end of the PEG chain is substituted with highly reactive thiol (-SH) group when PEG is reacted with a small molecule having an acetal group. Considering that PEG-OH has a low reactivity and it is difficult to react it with a single molecule by nucleophilic substitution, it is expected that the degree of activation will not largely different from that reported in *J. Polym. Sci. Ed*, 1984, 22, pp 341-352 (-65%).
- [11] US Patent No. 5,990,237 (Shearwater Polymers, Inc) presented a method of coupling PEG aldehydes to a variety of water soluble polymers (proteins, enzymes, polypeptides, drugs, dyes, nucleosides, oligonucleotides, lipids, phospholipids, liposomes, etc.) having amine groups, thereby preparing polymers stable in aqueous solution, without easily hydrolyzable groups, e.g. ester, in the polymer chain. However, the purity of PEG aldehydes given in the examples is variable (85-98%) depending on the reaction conditions.
- [12] WO 2004/013205 A1 (F. Hoffmann-La Roche AG) and US Patent No. 6,956,135 B2 (Sun Bio, Inc) presented substances having an aldehyde group at the terminus of the PEG chain but containing carbonyl groups or nitrogens within the PEG chain. They may exhibit different properties from the substances having a PEG chain consisting only of oxygen and hydrogen. Further, since the terminal functional group of the PEG chain is converted without intermediate purification processes, there is a high risk of byproduct (unreacted PEG) generation.

Disclosure of Invention

Technical Problem

- [13] An object of the present invention is to provide a method for preparing polyethyleneglycol (PEG) aldehyde derivatives capable of converting the hydroxyl group of PEG or derivatives one of the alcohol groups at the end of the PEG chain of which is substituted with alkoxy (hereinafter, alkoxy-PEG) to an aldehyde group.
- [14] More specifically, an object of the present invention is to provide a preparation method capable of economically preparing PEG aldehydes or alkoxy-PEG aldehydes from PEG or alkoxy-PEG such as mPEG, which are used to improve solubility and efficiency of drugs by attaching thereto, without impurities.

Technical Solution

- [15] The inventors of the present invention have found out that the production of low-molecular-weight PEG caused by the decomposition of the PEG chain can be minimized by oxidizing polyethyleneglycol (PEG) or alkoxy-PEG) under a mild condition (Pfitzner-Moffatt oxidation) to convert the terminal hydroxyl group to an aldehyde group, or by introducing a hydroxy(C3-C10)alkyl group at the terminus of PEG or alkoxy-PEG and then oxidizing it under a mild condition (Pfitzner-Moffatt oxidation) to convert the terminal hydroxyl group to an aldehyde group.
- [16] The preparation method in accordance with the present invention is deemed a commercially applicable economical method because the terminal alcohol group of macromolecules can be quantitatively converted into an aldehyde group without decomposition of the PEG chain, most of the reactants are commercially available substances, and the involved reaction does not require special preparation facilities (e.g. low temperature, high temperature, high pressure, etc.).
- [17] In a first embodiment, the present invention provides a method for preparing PEG aldehyde represented by Chemical Formula 1 by reacting a PEG derivative represented by Chemical Formula 2 with dimethyl sulfoxide and dicyclohexylcarbodiimide:
- [18] [Chemical Formula 1]
- [19] $\text{OHC}-(\text{CH}_2)_{m-1}-\text{O}-(\text{CH}_2\text{CH}_2\text{O})_n-(\text{CH}_2)_{m-1}-\text{CHO}$
- [20] [Chemical Formula 2]
- [21] $\text{HO}-(\text{CH}_2)_m-\text{O}-(\text{CH}_2\text{CH}_2\text{O})_n-(\text{CH}_2)_m-\text{OH}$
- [22] wherein
- [23] n represents an integer from 3 to 2000; and
- [24] m represents an integer from 2 to 10.
- [25] In a second embodiment, the present invention provides a method for preparing PEG aldehyde represented by Chemical Formula 10 by reacting a PEG derivative represented by Chemical Formula 11 with dimethyl sulfoxide and dicyclohexylcarbodiimide:
- [26] [Chemical Formula 10]
- [27] $\text{R}_2\text{O}-(\text{CH}_2\text{CH}_2\text{O})_n-(\text{CH}_2)_{m-1}-\text{CHO}$
- [28] [Chemical Formula 11]
- [29] $\text{R}_2\text{O}-(\text{CH}_2\text{CH}_2\text{O})_n-(\text{CH}_2)_m-\text{OH}$
- [30] wherein
- [31] n represents an integer from 3 to 2000;
- [32] m represents an integer from 2 to 10; and
- [33] R_2 is selected from (C1-C7)alkyl or (C6-C20)ar(C1-C7)alkyl.
- [34]

[35] Hereinafter, the embodiments of the present invention will be described in detail.

[36] Unless defined otherwise, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art. In the description, details of well-known features and techniques may be omitted to avoid unnecessarily obscuring the presented embodiments.

[37] The method for preparing PEG aldehyde according to the first embodiment of the present invention enables oxidation of the alcohol group of the compound represented by Chemical Formula 2 to aldehyde without decomposition of the PEG chain, thereby enabling preparation of PEG aldehyde represented by Chemical Formula 1 with high purity, with less impurities such as low-molecular weight PEG, PEG acid, etc. resulting from decomposition of the PEG chain:

[38] [Chemical Formula 1]

[39] $\text{OHC}-(\text{CH}_2)_{m-1}-\text{O}-(\text{CH}_2\text{CH}_2\text{O})_n-(\text{CH}_2)_{m-1}-\text{CHO}$

[40] [Chemical Formula 2]

[41] $\text{HO}-(\text{CH}_2)_m-\text{O}-(\text{CH}_2\text{CH}_2\text{O})_n-(\text{CH}_2)_m-\text{OH}$

[42] wherein

[43] n represents an integer from 3 to 2000; and

[44] m represents an integer from 2 to 10.

[45] More specifically, the above reaction is performed by mixing the PEG derivative represented by Chemical Formula 2 with dimethyl sulfoxide, trifluoroacetic acid and pyridine and then adding dicyclohexylcarbodiimide. Optionally, following the reaction, the product may be crystallized using a heptanes-isopropyl alcohol mixture and recrystallized using an acetonitrile (AN)-methyl t-butyl ether (MTBE) mixture.

[46] Of the method for preparing PEG aldehyde according to the first embodiment of the present invention, the method for preparing PEG aldehyde having a C3-C10 aldehyde group at the terminus of PEG specifically comprises: introducing a hydroxy(C3-C10)alkyl group at the terminus of PEG represented by Chemical Formula 3 to prepare a PEG derivative represented by Chemical Formula 4; and oxidizing the derivative represented by Chemical Formula 4 using dimethyl sulfoxide and dicyclohexylcarbodiimide to prepare PEG aldehyde represented by Chemical Formula 1:

[47] [Chemical Formula 3]

[48] $\text{HO}-(\text{CH}_2\text{CH}_2\text{O})_n-\text{H}$

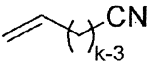
[49] [Chemical Formula 4]

[50] $\text{HO}-(\text{CH}_2)_k-\text{O}-(\text{CH}_2\text{CH}_2\text{O})_n-(\text{CH}_2)_k-\text{OH}$

[51] wherein

[52] n represents an integer from 3 to 2000; and

[53] k represents an integer from 3 to 10.

- [54] Specifically, the method for preparing the PEG derivative represented by Chemical Formula 4 comprises:
- [55] a) reacting PEG represented by Chemical Formula 3 with cyanoalkene represented by Chemical Formula 5 to prepare cyanoalkyl-PEG represented by Chemical Formula 6;
- [56] b) preparing PEG-carboxylic acid represented by Chemical Formula 7 from the cyanoalkyl-PEG represented by Chemical Formula 6;
- [57] c) reacting the PEG-carboxylic acid represented by Chemical Formula 7 with alcohol represented by Chemical Formula 8 to prepare a PEG-ester compound represented by Chemical Formula 9; and
- [58] d) reducing the PEG-ester compound represented by Chemical Formula 9 to prepare the PEG derivative represented by Chemical Formula 4:
- [59] [Chemical Formula 3]
- [60] $\text{HO}-(\text{CH}_2\text{CH}_2\text{O})_n-\text{H}$
- [61] [Chemical Formula 4]
- [62] $\text{HO}-(\text{CH}_2)_k-\text{O}-(\text{CH}_2\text{CH}_2\text{O})_n-(\text{CH}_2)_k-\text{OH}$
- [63] [Chemical Formula 5]
- [64] 
- [65] [Chemical Formula 6]
- [66] $\text{NC}-(\text{CH}_2)_{k-1}-\text{O}-(\text{CH}_2\text{CH}_2\text{O})_n-(\text{CH}_2)_{k-1}-\text{CN}$
- [67] [Chemical Formula 7]
- [68] $\text{HOOC}-(\text{CH}_2)_{k-1}-\text{O}-(\text{CH}_2\text{CH}_2\text{O})_n-(\text{CH}_2)_{k-1}-\text{COOH}$
- [69] [Chemical Formula 8]
- [70] R_1-OH
- [71] [Chemical Formula 9]
- [72] $\text{R}_1\text{OOC}-(\text{CH}_2)_{k-1}-\text{O}-(\text{CH}_2\text{CH}_2\text{O})_n-(\text{CH}_2)_{k-1}-\text{COOR}_1$
- [73] wherein
- [74] n represents an integer from 3 to 2000;
- [75] k represents an integer from 3 to 10; and
- [76] R_1 is selected from (C1-C7)alkyl or (C6-C20)ar(C1-C7)alkyl.
- [77] When preparing the PEG derivative represented by Chemical Formula 4, following one or more of the steps b) to d), a step of purifying the product by separating reaction byproduct, especially PEG and PEG acid, using an ion exchange resin column may be further included.
- [78] The method for preparing PEG aldehyde according to the second embodiment of the present invention enables oxidation of the alcohol group of the compound represented

by Chemical Formula 11 to aldehyde without decomposition of the PEG chain, thereby enabling preparation of PEG aldehyde represented by Chemical Formula 10 with high purity, with less impurities such as low-molecular weight PEG, PEG acid, etc. resulting from decomposition of the PEG chain:

[79] [Chemical Formula 10]

[80] $R_2O-(CH_2CH_2O)_n-(CH_2)_{m-1}-CHO$

[81] [Chemical Formula 11]

[82] $R_2O-(CH_2CH_2O)_n-(CH_2)_m-OH$

[83] wherein

[84] n represents an integer from 3 to 2000;

[85] m represents an integer from 2 to 10; and

[86] R_2 is selected from (C1-C7)alkyl or (C6-C20)ar(C1-C7)alkyl.

[87] More specifically, in Chemical Formula 11, R_2 may be exemplified by methyl, ethyl, propyl, butyl and benzyl.

[88] More specifically, the above reaction is performed by mixing the PEG derivative represented by Chemical Formula 11 with dimethyl sulfoxide, trifluoroacetic acid and pyridine and then adding dicyclohexylcarbodiimide. Optionally, following the reaction, the product may be crystallized using a heptanes-isopropyl alcohol mixture and recrystallized using an AN-MTBE mixture.

[89] Of the method for preparing PEG aldehyde according to the second embodiment of the present invention, the method for preparing PEG aldehyde having a C3-C10 aldehyde group at the terminus of PEG specifically comprises: introducing a hydroxy(C3-C10)alkyl group at the terminus of alkoxy-PEG represented by Chemical Formula 12 to prepare an alkoxy-PEG derivative represented by Chemical Formula 13; and oxidizing the derivative represented by Chemical Formula 13 using dimethyl sulfoxide and dicyclohexylcarbodiimide to prepare PEG aldehyde represented by Chemical Formula 10:

[90] [Chemical Formula 12]

[91] $R_2O-(CH_2CH_2O)_n-H$

[92] [Chemical Formula 13]

[93] $R_2O-(CH_2CH_2O)_n-(CH_2)_k-OH$

[94] wherein

[95] n represents an integer from 3 to 2000;

[96] k represents an integer from 3 to 10; and

[97] R_2 is selected from (C1-C7)alkyl or (C6-C20)ar(C1-C7)alkyl.

[98] More specifically, in Chemical Formulas 12 and 13, R_2 may be exemplified by methyl, ethyl, propyl, butyl and benzyl.

- [99] Specifically, the method for preparing the alkoxy-PEG derivative represented by Chemical Formula 13 comprises:
- [100] a) reacting alkoxy-PEG represented by Chemical Formula 12 with cyanoalkene represented by Chemical Formula 5 to prepare an alkoxy-PEG nitrile compound represented by Chemical Formula 14;
- [101] b) preparing alkoxy-PEG carboxylic acid represented by Chemical Formula 15 from the alkoxy-PEG nitrile compound represented by Chemical Formula 14;
- [102] c) reacting the alkoxy-PEG carboxylic acid represented by Chemical Formula 15 with alcohol represented by Chemical Formula 8 to prepare an alkoxy-PEG ester compound represented by Chemical Formula 16; and
- [103] d) reducing the alkoxy-PEG ester compound represented by Chemical Formula 16 to prepare the PEG derivative represented by Chemical Formula 13:
- [104] [Chemical Formula 12]
- [105] $R_2O-(CH_2CH_2O)_n-H$
- [106] [Chemical Formula 13]
- [107] $R_2O-(CH_2CH_2O)_n-(CH_2)_k-OH$
- [108] [Chemical Formula 5]
- [109] 
- [110] [Chemical Formula 14]
- [111] $R_2O-(CH_2CH_2O)_n-(CH_2)_{k-1}-CN$
- [112] [Chemical Formula 15]
- [113] $R_2O-(CH_2CH_2O)_n-(CH_2)_{k-1}-COOH$
- [114] [Chemical Formula 8]
- [115] R_1-OH
- [116] [Chemical Formula 16]
- [117] $R_2O-(CH_2CH_2O)_n-(CH_2)_{k-1}-COOR_1$
- [118] wherein
- [119] n represents an integer from 3 to 2000;
- [120] k represents an integer from 3 to 10; and
- [121] R_1 and R_2 are independently selected from (C1-C7)alkyl or (C6-C20)ar(C1-C7)alkyl.
- [122] More specifically, in Chemical Formulas 5, 8 and 12-16, R_1 and R_2 may be exemplified by methyl, ethyl, propyl, butyl and benzyl.
- [123] When preparing the PEG derivative represented by Chemical Formula 13, following one or more of the steps b) to d), a step of purifying the product by separating reaction byproduct, especially PEG and PEG acid, using an ion exchange resin column may be further included.

Advantageous Effects

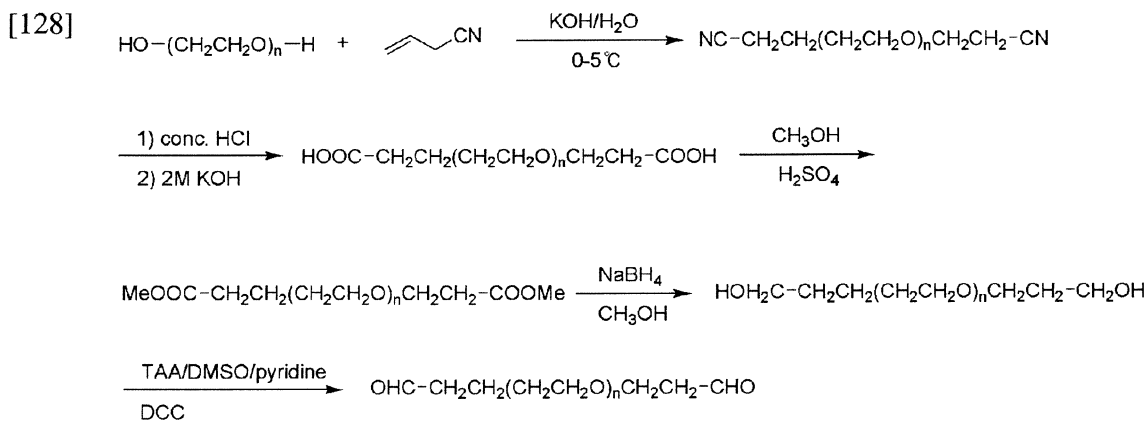
- [124] In the present invention, polyethyleneglycol (PEG) aldehydes or alkoxy-PEG aldehydes are prepared from PEG or alkoxy-PEG through cyanation, hydrolysis, esterification, reduction and oxidation. Byproducts produced from hydrolysis and reduction, especially PEG and PEG acid, can be minimized by separation and purification using an ion exchange resin column. The terminal alcohol group of macromolecules can be quantitatively converted to an aldehyde group without decomposition of the PEG chain. The preparation method in accordance with the present invention is deemed a commercially applicable economical method because the reactants are commercially available substances and the involved reaction does not require special preparation facilities (e.g. low temperature, high temperature, high pressure, etc.).

Mode for the Invention

- [125] The examples and experiments will now be described. The following examples and experiments are for illustrative purposes only and not intended to limit the scope of the present invention. Unless specified otherwise, % denotes mol%.

[126]

[127] [Example 1] Preparation of PEG-propionaldehyde



- [129] PEG-propionaldehyde was prepared according to the above reaction scheme. A detailed description of each step will be given below.

[130]

[131] Cyanation

- [132] PEG (number average molecular weight = 3.4 K, 100 g) is dissolved in distilled water (600 mL) in a reactor. KOH (45 g) is added and the mixture is cooled to 1-5 C. After the cooling, acrylonitrile (16 g) is added and the mixture is allowed to react for 3 days. Upon completion of the reaction, the mixture is extracted 3 times with MC (400 mL) and the solvent is completely removed.

[133] Yield: 110 g

[134] ¹H-NMR (200 MHz, CDCl₃): PEG backbone (m, 3.20-4.20 ppm), -OCH₂CH₂CN (t,

2.63 ppm)

[135]

[136] Hydrolysis and purification

[137] c-HCl (500 mL) is added to the concentrated residue (110 g) and the mixture is allowed to react at room temperature for 2 days. After extracting 3 times with MC (400 mL), MC is completely concentrated. 10% KOH solution (600 mL) is added to the concentrated residue (95 g) and the mixture is allowed to react at room temperature for 2 days. Upon completion of the reaction, the mixture is extracted 3 times with MC (300 mL) and the solvent layer is concentrated. Ethyl ether (1.2 L) is added and white powder (88 g) is obtained through crystallization at 0 C, filtration and drying. The dried white powder is purified using an ion exchange resin column.

[138] Yield: 52 g (HPLC purity: 99.94%)

[139] ¹H-NMR (200 MHz, CDCl₃): PEG backbone (m, 3.20-4.20 ppm), -OCH₂CH₂C(O)OH (t, 2.60 ppm)

[140]

[141] Esterification

[142] MeOH (400 mL) and H₂SO₄ (2.25 g) are added to the purified PEG diacid (52 g) and the mixture is allowed to react at room temperature for 2 days. After MC extracting 3 times with MC (300 mL), the solvent layer is completely concentrated.

[143] Yield: 51 g

[144] ¹H-NMR (200 MHz, CDCl₃): PEG backbone (m, 3.20-4.20 ppm), -OCH₃ (s, 3.50 ppm) -OCH₂CH₂C(O)OCH₃ (t, 2.60 ppm)

[145]

[146] Reduction and purification

[147] MC (30 mL) and MeOH (30 mL) are added to the concentrated residue (51 g). After stirring for 30 minutes, NaBH₄ (3 g) is added and the mixture is allowed to react for 24 hours. Upon completion of the reaction, most of the solvent is removed and, after adding 1 N-NaOH solution (400 mL), the mixture is stirred at an internal temperature of 80 C for 1 hour. After cooling, conc-HCl is added to adjust pH to 1.5-2 and the mixture is extracted 3 times with MC (200 mL). White powder (42 g) is obtained by crystallizing with methyl tert-butyl ether (MTBE, 600 mL), followed by filtration and drying. The dried white powder is purified using an ion exchange resin column.

[148] Yield: 30 g (HPLC purity: 100%)

[149] GPC: M_n (3023), PDI (polydispersity index) = 1.02

[150] ¹H-NMR (200 MHz, CDCl₃): PEG backbone (m, 3.20-4.20 ppm), -OCH₂CH₂CH₂OH (t, 2.62 ppm), -OCH₂CH₂CH₂OH (t, 1.83 ppm)

[151]

[152] Oxidation

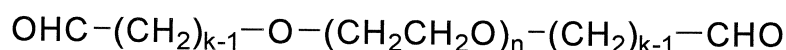
- [153] PEG propyl alcohol (42 g) is dissolved in MC (80 mL). After adding DMSO (94 mL), internal temperature is lowered to 0-5 C. After adding pyridine (3 g) and trifluoroacetic acid (TFA, 4 g), the mixture is stirred at the same temperature for 1 hour. After adding dicyclohexylcarbodiimide (DCC, 10 g), the mixture is allowed to react at room temperature for 24 hours. Upon completion of the reaction, precipitated dicyclohexylurea (DCU) is removed by filtration. Thereafter, previously prepared heptanes-isopropyl alcohol (IPA) (7:3 vol%, 1088 mL) is added and solid product is obtained by cooling and crystallization. The solid is recrystallized using AN-MTBE (5:1) and dried.
- [154] Yield: 25 g (by NMR purity: 99.73%)
- [155] GPC (mPEG): M_n (3156), PDI = 1.02
- [156] GPC: M_n (3010), PDI = 1.02
- [157] $^1\text{H-NMR}$ (500 MHz, CDCl_3): -C(O)H (s, 9.80 ppm), PEG backbone (m, 3.20-4.20 ppm), -OCH₂CH₂C(O)H (t, 2.60 ppm)
- [158]
- [159] [Example 2] Preparation of mPEG-propionaldehyde
- [160] mPEG (number average molecular weight = 20 K)-propionaldehyde was prepared from mPEG (number average molecular weight = 20 K) in the same manner as Example 1.
- [161] Yield: 60% (from mPEG, by NMR purity: 99.73%)
- [162] $^1\text{H-NMR}$ (500 MHz, CDCl_3): -C(O)H (s, 9.80 ppm), PEG backbone (m, 3.20-4.20 ppm), -OCH₂CH₂C(O)H (t, 2.60 ppm)
- [163]
- [164] [Example 3] Preparation of mPEG-acetaldehyde
- [165] mPEG acetaldehyde was prepared from mPEG (number average molecular weight = 5 K) through the same oxidation process as in Example 1. A detailed description will be given below.
- [166] mPEG (number average molecular weight = 5 K, 50 g) is dissolved in MC (100 mL). DMSO (100 mL) is added and the internal temperature is lowered to 0-5 C. After adding pyridine (5 g) and trifluoroacetic acid (TFA) (7 g), the mixture is stirred at the same temperature for 1 hour. After adding dicyclohexylcarbodiimide (DCC) (15 g), the mixture is allowed to react at room temperature for 24 hours. Upon completion of the reaction, precipitated dicyclohexylurea (DCU) is removed by filtration. Thereafter, previously prepared heptanes-IPA (7:3 vol%, 1000 mL) is added and solid product is obtained by cooling and crystallization. The solid is recrystallized using AN-MTBE (5:1) and dried.
- [167] Yield: 95% (from mPEG, by NMR purity: 99.73%)
- [168] $^1\text{H-NMR}$ (200 MHz, CDCl_3): -C(O)H (s, 9.67 ppm), PEG backbone (m, 3.20-4.20

ppm), -OCH₂C(O)H (s, 4.18 ppm)

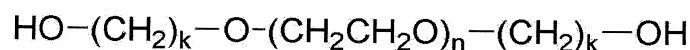
Claims

- [1] A method for preparing PEG aldehyde represented by Chemical Formula 1 by reacting a PEG derivative represented by Chemical Formula 4 with dimethyl sulfoxide and dicyclohexylcarbodiimide:

[Chemical Formula 1]



[Chemical Formula 4]



wherein

n represents an integer from 3 to 2000; and

k represents an integer from 3 to 10.

- [2] The method for preparing PEG aldehyde according to claim 1, wherein the PEG derivative represented by Chemical Formula 4 is mixed with dimethyl sulfoxide, trifluoroacetic acid and pyridine, and dicyclohexylcarbodiimide is added thereto.

- [3] The method for preparing PEG aldehyde according to claim 1, wherein, following the reaction, crystallization is performed using a heptanes-isopropyl alcohol mixture and recrystallization is performed using an acetonitrile-methyl t-butyl ether mixture.

- [4] The method for preparing PEG aldehyde according to claim 1, wherein the PEG derivative represented by Chemical Formula 4 is prepared by a process comprising:

reacting PEG represented by Chemical Formula 3 with cyanoalkene represented by Chemical Formula 5 to prepare cyanoalkyl-PEG represented by Chemical Formula 6;

preparing PEG-carboxylic acid represented by Chemical Formula 7 from the cyanoalkyl-PEG represented by Chemical Formula 6;

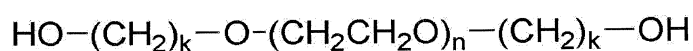
reacting the PEG-carboxylic acid represented by Chemical Formula 7 with alcohol represented by Chemical Formula 8 to prepare a PEG-ester compound represented by Chemical Formula 9; and

reducing the PEG-ester compound represented by Chemical Formula 9 to prepare the PEG derivative represented by Chemical Formula 4:

[Chemical Formula 3]



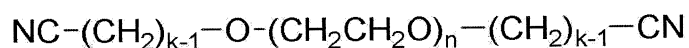
[Chemical Formula 4]



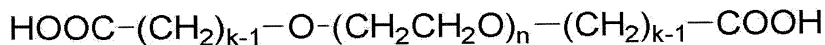
[Chemical Formula 5]



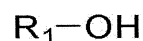
[Chemical Formula 6]



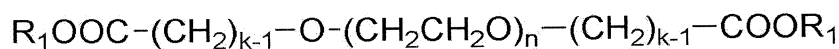
[Chemical Formula 7]



[Chemical Formula 8]



[Chemical Formula 9]



wherein

n represents an integer from 3 to 2000;

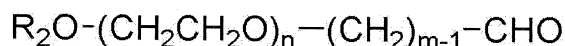
k represents an integer from 3 to 10; and

R₁ is selected from (C1-C7)alkyl or (C6-C20)ar(C1-C7)alkyl.

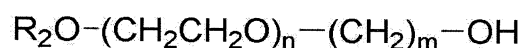
- [5] The method for preparing PEG aldehyde according to claim 4, further comprising, following one or more of said preparing the PEG-carboxylic acid represented by Chemical Formula 7 and said reducing the PEG-ester compound represented by Chemical Formula 9, separating reaction byproduct using an ion exchange resin column.

- [6] A method for preparing PEG aldehyde represented by Chemical Formula 10 by reacting a PEG derivative represented by Chemical Formula 11 with dimethyl sulfoxide and dicyclohexylcarbodiimide:

[Chemical Formula 10]



[Chemical Formula 11]



wherein

n represents an integer from 3 to 2000;

m represents an integer from 2 to 10; and

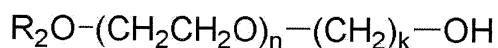
R₂ is selected from (C1-C7)alkyl or (C6-C20)ar(C1-C7)alkyl.

- [7] The method for preparing PEG aldehyde according to claim 6, wherein the PEG derivative represented by Chemical Formula 11 is mixed with dimethyl sulfoxide, trifluoroacetic acid and pyridine, and dicyclohexylcarbodiimide is added thereto.

- [8] The method for preparing PEG aldehyde according to claim 6, wherein, following the reaction, crystallization is performed using a heptanes-isopropyl alcohol mixture and recrystallization is performed using an acetonitrile-methyl t-butyl ether mixture.

- [9] The method for preparing PEG aldehyde according to claim 6, wherein the PEG derivative represented by Chemical Formula 11 is a PEG derivative represented by Chemical Formula 13:

[Chemical Formula 13]



wherein

n represents an integer from 3 to 2000;

k represents an integer from 3 to 10; and

R₂ is selected from (C1-C7)alkyl or (C6-C20)ar(C1-C7)alkyl.

[10] The method for preparing PEG aldehyde according to claim 9, wherein the PEG derivative represented by Chemical Formula 13 is prepared by a process comprising:

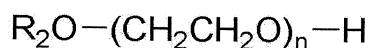
reacting alkoxy-PEG represented by Chemical Formula 12 with cyanoalkene
5 represented by Chemical Formula 5 to prepare an alkoxy-PEG nitrile compound represented by Chemical Formula 14;

preparing alkoxy-PEG carboxylic acid represented by Chemical Formula 15 from the alkoxy-PEG nitrile compound represented by Chemical Formula 14;

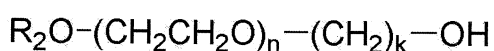
10 reacting the alkoxy-PEG carboxylic acid represented by Chemical Formula 15 with alcohol represented by Chemical Formula 8 to prepare an alkoxy-PEG ester compound represented by Chemical Formula 16; and

reducing the alkoxy-PEG ester compound represented by Chemical Formula 16 to prepare the PEG derivative represented by Chemical Formula 13:

[Chemical Formula 12]



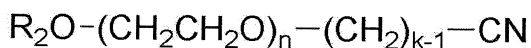
[Chemical Formula 13]



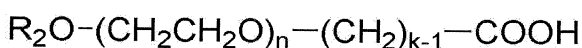
[Chemical Formula 5]



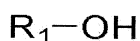
20 [Chemical Formula 14]



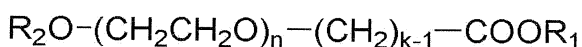
[Chemical Formula 15]



[Chemical Formula 8]



[Chemical Formula 16]



wherein

n represents an integer from 3 to 2000;

30 k represents an integer from 3 to 10; and

R_1 and R_2 are independently selected from (C1-C7)alkyl or (C6-C20)ar(C1-C7)alkyl.

- 5 [11] The method for preparing PEG aldehyde according to claim 10, further comprising, following one or more of said preparing the alkoxy-PEG carboxylic acid represented by Chemical Formula 15 and said reducing the alkoxy-PEG ester compound represented by Chemical Formula 16, separating reaction byproduct using an ion exchange resin column.