PROCESS FOR THE DEPOLYMERIZATION OF POLYETHYLENE TEREPHTHALATE (PET)

CROSS-REFERENCE

[0001] This application claims the benefit of U. S. Provisional Application Serial No. 62/821,270 filed March 20, 2019 which is hereby incorporated by reference in its entirety.

FIELD OF THE INVENTION

[0002] The present disclosure relates to the formation of dimethyl terephthalate (DMT) and mono ethylene glycol (MEG) from polyethylene terephthalate (PET).

BACKGROUND OF THE INVENTION

[0003] The polyethylene terephthalate (PET) bottle resin market has been growing strongly as PET resins have replaced glass in carbonated soft drink, bottled water and food containers.

[0004] Dimethyl terephthalate (DMT) is primarily used in the manufacture of polyethylene terephthalate (PET) for fiber, film, container plastics, and specialty plastics applications.

[0005] The largest polyester sector is the fibers market where it is used to make clothes, home textiles, such as sheets and curtains, carpets and rugs, and industrial products, such as tire cord, seat belts, hoses and ropes. PET film is utilized in electrical applications, such as dielectric metal foil capacitors, and for food packaging.

SUMMARY

[0005a] In a first aspect, the present disclosure refers to a process for the depolymerization of polyethylene terephthalate (PET) comprised in a feedstock to form dimethyl terephthalate (DMT) and mono ethylene glycol (MEG); the process comprising:

(i) mixing the feedstock comprising polyethylene terephthalate (PET) with a first portion of methanol to form a first mixture;

(ii) adding sodium methoxide to the first mixture;

(iii) admixing; and

(iv) adding a second portion of methanol thereby forming a second mixture;

thereby forming dimethyl terephthalate (DMT) and mono ethylene glycol (MEG).

[0006] Disclosed herein is a process for the depolymerization of polyethylene terephthalate (PET) comprised in a feedstock to form dimethyl terephthalate (DMT) and mono ethylene glycol (MEG); the process comprising:

(i) mixing the feedstock comprising polyethylene terephthalate (PET) with a first portion of methanol to form a first mixture;

(ii) adding sodium methoxide to the first mixture;

(iii) admixing; and

(iv) adding a second portion of methanol thereby forming a second mixture;

thereby forming dimethyl terephthalate (DMT) and mono ethylene glycol (MEG).

[0007] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), the amount of the first portion of methanol is between about 0.1 and about 0.5 kg/kg of feedstock.

[0008] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), the amount of the first portion of methanol is about 0.3 kg/kg of feedstock.

[0009] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), step (i) is conducted for about 15 mins to about 120 mins.

[0010] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), step (i) is conducted for about 60 min.

[0011] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), step (i) is conducted at a temperature between about 50°C to about 100°C.

[0012] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), step (i) is conducted at a temperature between about 60°C to about 90°C.

[0013] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), step (i) is conducted at a temperature of about 60°C.

[0014] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), step (i) is conducted at a temperature of about 80°C.

[0015] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), step (iii) is conducted for about 10 min to about 120 min.

[0016] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), step (iii) is conducted for about 30 min.

[0017] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), step (iii) is conducted at a temperature between about 40°C to about 100°C.

[0018] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), step (iii) is conducted at a temperature of between about 85°C to about 90°C.

[0019] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), the second portion of methanol is provided to maintain the sodium methoxide concentration in the second mixture between about 0.2 wt-% and about 5.0 wt-%.

[0020] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), the second portion of methanol is provided to maintain the sodium methoxide concentration in the second mixture between about 0.5 wt-% and about 1.5 wt-%.

[0021] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), the second portion of methanol is provided to maintain the sodium methoxide concentration in the second mixture at about 0.7 wt-%.

[0022] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), the second portion of methanol is provided in fractions at predetermined times.

[0023] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), a first fraction of the second portion of methanol is provided about 1 min to about 60 min after the addition of sodium methoxide.

[0024] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), a first fraction of the second portion of methanol is provided about 30 min after the addition of sodium methoxide.

[0025] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), the amount of the first fraction of the second portion of methanol is between about 50 g/kg of feedstock and about 100 g/kg of feedstock.

[0026] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), a second fraction of the second portion of methanol is provided about 30 min to about 90 min after the addition of sodium methoxide.

[0027] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), a second fraction of the second portion of methanol is provided about 60 min after the addition of sodium methoxide.

[0028] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), the amount of the second fraction of the second portion of methanol is between about 100 g/kg of feedstock and about 200 g/kg of feedstock.

[0029] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), a third fraction of the second portion of methanol is provided about 60 min to about 120 min after the addition of sodium methoxide.

[0030] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), a third fraction of the second portion of methanol is provided about 90 min after the addition of sodium methoxide.

[0031] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), the amount of the third fraction of the second portion of methanol is between about 100 g/kg of feedstock and about 200 g/kg of feedstock.

[0032] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), the second portion of methanol is provided continuously.

[0033] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), the second portion of methanol is provided continuously at a rate between about 50 g/h/kg of feedstock and about 100 g/h/kg of feedstock.

[0034] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), the ratio of sodium methoxide to polyethylene terephthalate (PET) is between about 1:2 and about 1:28 (mol/mol).

[0035] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), the ratio of sodium methoxide to polyethylene terephthalate (PET) is between about 1:5 and about 1:20 (mol/mol).

[0036] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), the ratio of sodium methoxide to polyethylene terephthalate (PET) is between about 1:10 and about 1:20 (mol/mol).

[0037] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), the ratio of sodium methoxide to polyethylene terephthalate (PET) is between about 1:10 and about 1:15 (mol/mol).

[0038] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), the dimethyl terephthalate is obtained in at least about 90 mol% yield.

[0039] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), the dimethyl terephthalate is obtained in at least about 95 mol% yield.

[0040] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), the dimethyl terephthalate is obtained in at least about 99 mol% yield.

[0041] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), the mono ethylene glycol is obtained in at least about 80 mol% yield.

[0042] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), the mono ethylene glycol is obtained in at least about 85 mol% yield.

[0043] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), the mono ethylene glycol is obtained in at least about 90 mol% yield.

[0044] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), the feedstock comprising polyethylene terephthalate (PET) is provided in the form of particles.

[0045] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), the average particle size is between about 0.1 mm and about 20 mm.

[0046] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), the average particle size is between about 5 mm and about 10 mm.

[0047] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), the average particle size is up to about 6 mm.

[0048] In some examples of a process for the depolymerization of polyethylene terephthalate (PET), the average particle size is up to about 8 mm.

DETAILED DESCRIPTION OF THE INVENTION

[0049] Dimethyl terephthalate (DMT) is used in the production of polyesters, including polyethylene terephthalate (PET), polytrimethylene terephthalate (PTT), and polybutylene terephthalate (PBT). Because DMT is volatile, it is an intermediate in some schemes for the recycling of PET, e.g. from plastic bottles. Hydrogenation of DMT affords the diol 1, 4-cyclohexanedimethanol, which is a useful monomer in the formation of polyester resins.

[0050] DMT has been produced in a number of ways. Conventionally, and still of commercial value, is the direct esterification of terephthalic acid. Alternatively, it is prepared by alternating oxidation and methyl-esterification steps from para-xylene via methyl para-toluate. The method for the production of DMT from para-xylene and methanol consists of four major steps: oxidation, esterification, distillation, and crystallization. A mixture of para-xylene and para-toluic ester is oxidized with air in the presence of a transition metal catalyst (Co/Mn). The acid mixture resulting from the oxidation is esterified with

CLAIMS

What is claimed is:

1. A process for the depolymerization of polyethylene terephthalate (PET) comprised in a feedstock to form dimethyl terephthalate (DMT) and mono ethylene glycol (MEG); the process comprising:
(i) mixing the feedstock comprising polyethylene terephthalate (PET) with a first portion of methanol to form a first mixture;
(ii) adding sodium methoxide to the first mixture;
(iii) admixing; and
(iv) adding a second portion of methanol thereby forming a second mixture;
thereby forming dimethyl terephthalate (DMT) and mono ethylene glycol (MEG).
2. The process of claim 1, wherein the amount of the first portion of methanol is between about 0.1 and about 0.5 kg/kg of feedstock.
3. The process of claim 1 or 2, wherein step (i) is conducted for about 15 mins to about 120 mins.
4. The process of any one of claims 1-3, wherein step (i) is conducted at a temperature between about 50°C to about 100°C.
5. The process of any one of claims 1-4, wherein step (iii) is conducted for about 10 min to about 120 min.
6. The process of any one of claims 1-5, wherein step (iii) is conducted at a temperature between about 40°C to about 100°C.
7. The process of any one of claims 1-6, wherein the second portion of methanol is provided to maintain the sodium methoxide concentration in the second mixture between about 0.2 wt-% and about 5.0 wt-%.
8. The process of any one of claims 1-7, wherein the second portion of methanol is provided in fractions at predetermined times.
9. The process of claim 8, wherein a first fraction of the second portion of methanol is provided about 1 min to about 60 min after the addition of sodium methoxide.
10. The process of claim 9, wherein the amount of the first fraction of the second portion of methanol is between about 50 g/kg of feedstock and about 100 g/kg of feedstock.
11. The process of any one of claims 8-10, wherein a second fraction of the second portion of methanol is provided about 30 min to about 90 min after the addition of sodium methoxide.
12. The process of claim 11, wherein the amount of the second fraction of the second portion of methanol is between about 100 g/kg of feedstock and about 200 g/kg of feedstock.
13. The process of any one of claims 8-12, wherein a third fraction of the second portion of methanol is provided about 60 min to about 120 min after the addition of sodium methoxide.
14. The process of claim 13, wherein the amount of the third fraction of the second portion of methanol is between about 100 g/kg of feedstock and about 200 g/kg of feedstock.

15. The process of any one of claims 1-14, wherein the second portion of methanol is provided continuously.
16. The process of claim 15, wherein the second portion of methanol is provided continuously at a rate between about 50 g/h/kg of feedstock and about 100 g/h/kg of feedstock.
17. The process of any one of claims 1-16, wherein the ratio of sodium methoxide to polyethylene terephthalate (PET) is between about 1:2 and about 1:28 (mol/mol).
18. The process of any one of claims 1-17, wherein the dimethyl terephthalate is obtained in at least about 90 mol% yield.
19. The process of any one of claims 1-18, wherein the feedstock comprising polyethylene terephthalate (PET) is provided in the form of particles.
20. The process of claim 19, wherein the average particle size is between about 0.1 mm and about 20 mm.