~~To solve the problems described above, the present invention has the following constitution.~~

~~(1) A battery separator, comprising: a porous membrane A comprising a polyethylene resin, and a porous membrane B laminated thereon comprising a heat resistant resin and inorganic particles or cross-linked polymer particles,~~

~~wherein the porous membrane A satisfies expressions (a) to (e) below, and the entire battery separator satisfies (d) to (f).~~In a first aspect, there is provided a battery separator, comprising: a porous membrane A comprising a polyethylene resin, and a porous membrane B laminated thereon comprising a heat resistant resin and inorganic particles or cross-linked polymer particles, wherein the porous membrane A satisfies expressions (a) to (c) below, the entire battery separator satisfies (d) to (f), and the heat resistant resin comprises a fluororesin:

$$t(A) \leq 10\ \mu m \quad \text{Expression (a)}$$

wherein t (A) is a thickness of the porous membrane A;

$$0.01\ \mu m \leq R(A) \leq 1.0\ \mu m \quad \text{Expression (b)}$$

wherein R (A) is an average pore size of the porous membrane A;

$$30\% \leq V(A) \leq 70\% \quad \text{Expression (c)}$$

wherein V (A) is a porosity of the porous membrane A;

$$t(T) \leq 13\ \mu m \quad \text{Expression (d)}$$

wherein t (T) is a thickness of the battery separator;

$$F(A/B) \geq 1.0\ N/25\ mm \quad \text{Expression (e)}$$

wherein F (A/B) is a peeling strength at the interface between the porous membrane A and the porous membrane B; and

$$20 \leq Y - X \leq 100 \quad \text{Expression (f)}$$

wherein X is an air resistance (sec/100 cc Air) of the porous membrane A, and Y is an air resistance (sec/100 cc Air) of the entire battery separator.

[0023]

~~t (A) < 10 μm Expression (a)~~

~~wherein t (A) is a thickness of the porous membrane A;~~

~~0.01 μm ≤ R (A) ≤ 1.0 μm Expression (b)~~

~~wherein R (A) is an average pore size of the porous membrane A;~~

~~30% ≤ V (A) ≤ 70% Expression (c)~~

~~wherein V (A) is a porosity of the porous membrane A;~~

~~t (T) ≤ 13 μm Expression (d)~~

~~wherein t (T) is a thickness of the battery separator;~~

~~F (A/B) ≥ 1.0 N/25 mm Expression (e)~~

~~wherein F (A/B) is a peeling strength at the interface between the porous membrane A and the porous membrane B; and~~

~~20 ≤ Y - X ≤ 100 Expression (f)~~

~~wherein X is an air resistance (sec/100 cc Air) of the porous membrane A, and~~

~~Y is an air resistance (sec/100 cc Air) of the entire battery separator.~~

~~(2) The battery separator according to (1), wherein~~In an embodiment, the battery separator may have~~has~~ an air resistance Y of 50 to 600 sec/100 cc Air.

~~(3) The battery separator according to (1) or (2), wherein~~In an embodiment, the heat resistant resin may comprise~~comprises~~ a polyamide-imide resin, a polyimide resin, or a polyamide resin.

~~(4) The battery separator according to (1) or (2), wherein~~In an embodiment, the heat resistant resin

may comprisecomprises a fluororesin.

(5) A process for producing the battery separator according to any one of (1) to (4), comprising the following steps (i) and (ii).

[0024]

Step (i): applying a varnish comprising a heat resistant resin and inorganic particles to a porous membrane A comprising a polyethylene resin, and then passing the porous membrane A through a low humidity zone at an absolute humidity of not less than 0.5 g/m^3 and less than 6 g/m^3 and a high humidity zone at an absolute humidity of not less than 7.0 g/m^3 and less than 25.0 g/m^3 to form a heat resistant resin membrane on the porous membrane A; and

Step (ii): immersing the composite membrane obtained in the step (i), in which the heat resistant resin membrane is laminated, in a coagulation bath to convert the heat resistant resin membrane into a porous membrane B, and washing and drying the porous membrane B to obtain a battery separator.In a second aspect, there is provided a process for producing the battery separator according to the present invention, comprising: the following steps (i) and (ii): Step (i): applying a varnish comprising a heat resistant resin which comprises a fluororesin and inorganic particles to a porous membrane A comprising a polyethylene resin, and then passing the porous membrane A through a low humidity zone at an absolute humidity of not less than 0.5 g/m^3 and less than 6 g/m^3 and a high humidity zone at an absolute humidity of not less than 7.0 g/m^3 and less than 25.0 g/m^3 to form a heat resistant resin membrane on the porous membrane A; and Step (ii): immersing the composite membrane obtained in the step (i), in which the heat resistant resin membrane is laminated, in a coagulation bath to convert the heat resistant resin membrane into a porous membrane B, and washing and drying the porous membrane B to obtain a battery separator.

EFFECTS OF THE INVENTION

[0025]

In embodiments of the present invention, the heat resistant resin layer and the polyethylene porous membrane have excellent adhesion, and even when the heat resistant resin layer is laminated, the amount of air resistance increase (which hereinafter may be abbreviated as the amount of air resistance increase) is small compared to the air resistance of the polyethylene porous membrane alone. Thus, the battery separator as per embodiments of the present invention has excellent heat resistance and, at the same time, excellent ion permeability. Further, the battery separator as per embodiments of the present invention is characterized by having excellent adhesion between the polyethylene porous membrane, a substrate, and the heat resistant resin layer (which hereinafter may be referred to simply as adhesion of the heat resistant resin layer), and excellent processability (low curling properties) in a battery assembly process. In addition,

the battery separator as per embodiments of the present invention is also characterized by small variation in air resistance.

DESCRIPTION OF EMBODIMENTS

[0026]

In the present invention, when laminating a heat resistant resin layer containing particles on a polyethylene porous membrane having a thickness of less than 10 μm, an advanced processing technique was used to provide excellent adhesion of the heat resistant resin layer due to appropriately formed anchoring of the heat resistant resin layer without causing significant increase in air resistance.

[0027]

"Significant increase in air resistance" herein means that the difference between an air resistance (X) of the porous membrane A that serves as a substrate and an air resistance (Y) of the composite porous membrane (battery separator) is more than 100 sec/100 cc Air.

[0028]

The summary of the battery separator of the present invention will be described, but the present invention is, of course, not limited to this representative example.

[0029]

First, the porous membrane A used in the present invention will be described.

[0030]

The resin that constitutes the porous membrane A is a polyethylene resin and may be a single substance, a mixture of two or more different polyethylene resins, for example, a mixture of polyethylene and polypropylene, or a copolymer of different olefins. This is because polyethylene and polypropylene have, in addition to basic properties such as electrical insulating properties and ion permeability, such a pore-blocking effect that excessive temperature rise is suppressed by blocking a

CLAIMS

1. A battery separator, comprising: a porous membrane A comprising a polyethylene resin, and a porous membrane B laminated thereon comprising a heat resistant resin and inorganic particles or cross-linked polymer particles,

wherein the porous membrane A satisfies expressions (a) to (c) below, and the entire battery separator satisfies (d) to (f):

$$t(A) < 10\ \mu m \quad \text{Expression (a)}$$

wherein t (A) is a thickness of the porous membrane A;

$$0.01\ \mu m \leq R(A) \leq 1.0\ \mu m \quad \text{Expression (b)}$$

wherein R (A) is an average pore size of the porous membrane A;

$$30\% \leq V(A) \leq 70\% \quad \text{Expression (c)}$$

wherein V (A) is a porosity of the porous membrane A:

$$t(T) \leq 13\ \mu m \quad \text{Expression (d)}$$

wherein t (T) is a thickness of the battery separator;

$$F(A/B) \geq 1.0\ N/25\ mm \quad \text{Expression (e)}$$

wherein F (A/B) is a peeling strength at the interface between the porous membrane A and the porous membrane B; and

$$20 \leq Y - X \leq 100 \quad \text{Expression (f)}$$

wherein X is an air resistance (sec/100 cc Air) of the porous membrane A, and Y is an air resistance (sec/100 cc Air) of the entire battery separator.

2. The battery separator according to claim 1, wherein the battery separator has an air resistance Y of 50 to 600 sec/100 cc Air.

3. The battery separator according to claim 1 or 2, wherein the heat resistant resin comprises a polyamide-imide resin, a polyimide resin, or a polyamide resin.

4. The battery separator according to claim 1 or 2, wherein the heat resistant resin comprises a fluororesin.

5. A process for producing the battery separator according to any one of claims

1 to 4, comprising: the following steps (i) and (ii);

Step (i): applying a varnish comprising a heat resistant resin and inorganic particles to a porous membrane A comprising a polyethylene resin, and then passing the porous membrane A through a low humidity zone at an absolute humidity of not less than 0.5 g/m^3 and less than 6 g/m^3 and a high humidity zone at an absolute humidity of not less than 7.0 g/m^3 and less than 25.0 g/m^3 to form a heat resistant resin membrane on the porous membrane A; and

Step (ii): immersing the composite membrane obtained in the step (i), in which the heat resistant resin membrane is laminated, in a coagulation bath to convert the heat resistant resin membrane into a porous membrane B, and washing and drying the porous membrane B to obtain a battery separator.

Claims

[Claim 1] A battery separator, comprising: a porous membrane A comprising a polyethylene resin, and a porous membrane B laminated thereon comprising a heat resistant resin and inorganic particles or cross-linked polymer particles,
wherein the porous membrane A satisfies expressions (a) to (c) below, the entire battery separator satisfies (d) to (f), and the heat resistant resin comprises a fluororesin:

$t(A) < 10\ \mu m$ Expression (a)

wherein t (A) is a thickness of the porous membrane A;

$0.01\ \mu m \leq R(A) \leq 1.0\ \mu m$ Expression (b)

wherein R (A) is an average pore size of the porous membrane A;

$30\% \leq V(A) \leq 70\%$ Expression (c)

wherein V (A) is a porosity of the porous membrane A:

$t(T) \leq 13\ \mu m$ Expression (d)

wherein t (T) is a thickness of the battery separator;

$F(A/B) \geq 1.0\ N/25\ mm$ Expression (e)

wherein F (A/B) is a peeling strength at the interface between the porous membrane A and the porous membrane B; and

$20 \leq Y - X \leq 100$ Expression (f)

wherein X is an air resistance (sec/100 cc Air) of the porous membrane A, and
Y is an air resistance (sec/100 cc Air) of the entire battery separator.

[Claim 2] A process for producing the battery separator according to claim 1, comprising: the following steps (i) and (ii);

Step (i): applying a varnish comprising a heat resistant resin which comprises a fluororesin and inorganic particles to a porous membrane A comprising a polyethylene resin, and then passing the porous membrane A through a low humidity zone at an absolute humidity of not less than 0.5 g/m^3 and less than 6 g/m^3 and a high humidity zone at an absolute humidity of not less than 7.0 g/m^3 and less than 25.0 g/m^3 to form a heat resistant resin membrane on the porous membrane A; and

Step (ii): immersing the composite membrane obtained in the step (i), in which the heat resistant resin membrane is laminated, in a coagulation bath to convert the heat resistant resin membrane into a porous membrane B, and washing and drying the porous membrane B to obtain a battery separator.