Claims

[Claim 1] A thin-film-composite hollow-fiber membrane comprising:
a phase-inversion layer in the form of a hollow fiber substrate; and
an active layer coated on the phase-inversion layer, wherein the active layer selectively allows passage of water molecules but rejects at least some dissolved ions,
wherein the thin-film-composite hollow-fiber membrane has an internal burst pressure of at least 4 MPa.

[Claim 2] The thin-film-composite hollow-fiber membrane of claim 1, wherein the phase-inversion layer is an outer layer and the active layer is an inner layer.

[Claim 3] The thin-film-composite hollow-fiber membrane of claim 1, wherein the phase-inversion layer is formed of at least one of polyethersulfone and polysulfone.

[Claim 4] The thin-film-composite hollow-fiber membrane of claim 1, wherein the active layer is formed via an interfacial polymerization process.

[Claim 5] The thin-film-composite hollow-fiber membrane of claim 1, wherein the phase-inversion layer comprises a finger-like macrovoid region and a sponge-like region.

[Claim 6] The thin-film-composite hollow-fiber membrane of claim 5, wherein the phase-inversion layer has a wall thickness, the finger-like macrovoid region has a thickness, and the thickness of the finger-like macrovoid region is no greater than 70% of the wall thickness.

[Claim 7] The thin-film-composite hollow-fiber membrane of claim 1, wherein the internal burst pressure is at least 7 MPa.

[Claim 8] The thin-film-composite hollow-fiber membrane of claim 1, wherein the internal burst pressure is at least 10 MPa.

[Claim 9] The thin-film-composite hollow-fiber membrane of claim 1, wherein the active layer has a thickness that is between 100 and 600 nm.

[Claim 10] The thin-film-composite hollow-fiber membrane of claim 1, wherein the hollow-fiber membrane has an outer diameter between 800 and 1200 um.

[Claim 11] The thin-film-composite hollow-fiber membrane of claim 1, wherein the hollow-fiber membrane has an inner diameter between 150 and 500 um.

[Claim 12] The thin-film-composite hollow-fiber membrane of claim 1, wherein the hollow-fiber membrane has a wall thickness of at least 250 um.

[Claim 13] The thin-film-composite hollow-fiber membrane of claim 1, wherein the hollow-fiber membrane has a wall thickness of at least 350 um.

[Claim 14] The thin-film-composite hollow-fiber membrane of claim 1, wherein the hollow-fiber membrane has a porosity between 55% and 80%.

[Claim 15] The thin-film-composite hollow-fiber membrane of claim 1, wherein the hollow-fiber membrane has a maximum tensile stress of at least 5.5 MPa.

[Claim 16] The thin-film-composite hollow-fiber membrane of claim 1, wherein the hollow-fiber membrane has a Young's Modulus of at least 170 MPa.

[Claim 17] The thin-film-composite hollow-fiber membrane of claim 1, wherein the hollow-fiber membrane has a structural parameter below 0.9 mm.

[Claim 18] The thin-film-composite hollow-fiber membrane of claim 1, wherein the hollow-fiber membrane has a pure water permeability of at least 25 LMH/MPa.

[Claim 19] The thin-film-composite hollow-fiber membrane of claim 1, wherein the hollow-fiber membrane has a NaCl rejection rate of at least 90%.

[Claim 20] The thin-film-composite hollow-fiber membrane of claim 1, wherein the hollow-fiber membrane has a NaCl rejection rate of at least 97%.

~~[Claim 21] A method for synthesizing a thin-film-composite hollow-fiber membrane, comprising:~~

~~forming a spinning dope comprising a polymer, a polar solvent, a pore-forming additive, a nonsolvent, and a mineral additive;~~

~~providing a spinneret that has an external orifice and an internal orifice;~~

~~extruding the spinning dope through the external orifice through an air gap into a coagulation bath containing a coagulant and simultaneously flowing a bore fluid through the internal orifice to form a hollow-fiber substrate;~~

~~post-treating the hollow-fiber substrate by immersion in a glycerol solution; and~~

~~forming an active layer on a surface of the hollow-fiber substrate, wherein~~

~~the thin-film-composite hollow-fiber membrane has a burst pressure of at least 4 MPa.~~

~~[Claim 22] The method of claim 21, wherein the active layer is formed on an inner surface of the hollow-fiber substrate.~~

~~[Claim 23] The method of claim 21, wherein the polymer concentration in the spinning dope is no greater than 5% below a critical concentration at which extensive polymer chain entanglement occurs.~~

~~[Claim 24] The method of claim 21, wherein the polymer concentration is at least 20%.~~

~~[Claim 25] The method of claim 21, wherein the spinning dope is extruded at a dope rate, the bore fluid is flowed at a bore rate, and the ratio of the dope rate to the bore rate is at least 2.~~

~~[Claim 26] The method of claim 21, wherein the spinning dope is extruded at a dope rate, the bore fluid is flowed at a bore rate, and the ratio of the dope rate to the bore rate is at least 10.~~

~~[Claim 27] The method of claim 21, wherein the polymer includes at least one of polyethersulfone and polysulfone.~~

~~[Claim 28] The method of claim 21, wherein the polar solvent comprises N-methyl-2-pyrrodlidone, dimethylformamide, and/or dimethyl sulfoxide.~~

~~[Claim 29] The method of claim 21, wherein the pore-forming additive is polyethylene glycol having a molecular weight of about 400 g/mol.~~

~~[Claim 30] The method of claim 21, wherein the nonsolvent is deionized water.~~

~~[Claim 31] The method of claim 21, wherein the mineral additive is calcium chloride.~~

~~[Claim 32] The method of claim 21, wherein the coagulant is water.~~

~~[Claim 33] The method of claim 21, wherein the concentration of glycerol solution contains 50% glycerol by weight and 50% water by weight.~~

~~[Claim 34] The method of claim 21, wherein forming an active layer comprises flowing a first solution comprising M-phenylenediamine and sodium dodecyl sulphate across a surface of the hollow-fiber substrate, and flowing a second solution comprising trimesoyl chloride and hexane across the surface of the hollow-fiber substrate.~~

~~[Claim 35] The method of claim 34, wherein the concentration of M-phenylenediamine in the first solution is about 2%.~~

~~[Claim 36] The method of claim 34, wherein the concentration of sodium dodecyl sulphate in the first solution is about 0.1%.~~

~~[Claim 37] The method of claim 34, wherein the concentration of trimesoyl chloride is about 0.15%.~~

~~[Claim 38] The method of claim 21, wherein the spinning dope is extruded at a rate of 2 to 4 ml/min.~~

~~[Claim 39] The method of claim 21, wherein the bore fluid is flowed at a rate of 0.3 to 1 ml/min.~~

~~[Claim 40] The method of claim 21, wherein the bore fluid comprises water.~~

~~[Claim 41] The method of claim 21, wherein the coagulant bath has a temperature of about 25 °C.~~

~~[Claim 42] The method of claim 21, further comprising potting two or more thin-film-composite hollow-fiber membranes to form a membrane module.~~

~~[Claim 43] A method for synthesizing a thin-film-composite hollow-fiber membrane, comprising:~~

~~forming a spinning dope comprising a polymer, a polar solvent, a pore-forming additive, a nonsolvent, and a mineral additive;~~

~~providing a spinneret that has an external orifice and an internal orifice;~~

~~extruding the spinning dope through the external orifice through an air gap into a coagulation bath containing a coagulant and simultaneously flowing a bore fluid through the internal orifice to form a hollow-fiber substrate;~~

~~post-treating the hollow-fiber substrate by immersion in a glycerol solution; and~~

~~forming an active layer on an inner or outer surface of the hollow-fiber substrate, wherein~~

~~the polymer concentration in the spinning dope is no greater than 5% below a critical concentration at which extensive polymer chain entanglement occurs.~~

~~[Claim 44] The method of claim 43, wherein the active layer is formed on an inner surface of the hollow-fiber substrate.~~

~~[Claim 45] The method of claim 43, wherein the polymer concentration is at least 20%.~~

~~[Claim 46] The method of claim 43, wherein the spinning dope is extruded at a dope rate, the bore fluid is flowed at a bore rate, and the ratio of the dope rate to the bore rate is at least 2.~~

~~[Claim 47] The method of claim 43, wherein the spinning dope is extruded at a dope rate, the bore fluid is flowed at a bore rate, and the ratio of the dope rate to the bore rate is at least 10.~~

~~[Claim 48] The method of claim 43, wherein the polymer includes at least one of polyethersulfone and polysulfone.~~

~~[Claim 49] The method of claim 43, wherein the polar solvent comprises at least one of N-methyl-2-pyrrodlidone, dimethylformamide, and dimethyl sulfoxide.~~

~~[Claim 50] The method of claim 43, wherein the pore-forming additive is polyethylene glycol having a molecular weight of about 400 g/mol.~~

~~[Claim 51] The method of claim 43, wherein the nonsolvent is deionized water.~~

~~[Claim 52] The method of claim 43, wherein the mineral additive is calcium chloride.~~

~~[Claim 53] The method of claim 43, wherein the coagulant is water.~~

~~[Claim 54] The method of claim 43, wherein the concentration of glycerol solution contains 50% glycerol by weight and 50% water by weight.~~

~~[Claim 55] The method of claim 43, wherein forming an active layer comprises flowing a first solution comprising M-phenylenediamine and sodium dodecyl sulphate across a surface of the hollow-fiber substrate, and flowing a second solution comprising trimesoyl chloride and hexane across the surface of the hollow-fiber substrate.~~

~~[Claim 56] The method of claim 55, wherein the concentration of M-phenylenediamine in the first solution is about 2%.~~

~~[Claim 57] The method of claim 55, wherein the concentration of sodium dodecyl sulphate in the first solution is about 0.1%.~~

~~[Claim 58] The method of claim 55, wherein the concentration of trimesoyl chloride is about 0.15%.~~

~~[Claim 59] The method of claim 55, wherein the spinning dope is extruded at a rate of 2 to 4 ml/min.~~

~~[Claim 60] The method of claim 43, wherein the bore fluid is flowed at a rate of 0.3 to 1 ml/min.~~

~~[Claim 61] The method of claim 43, wherein the bore fluid comprises water.~~

~~[Claim 62] The method of claim 43, wherein the coagulant bath has a temperature of about 25 °C.~~

~~[Claim 63] The method of claim 43, further comprising potting two or more thin-film-composite hollow-fiber membranes to form a membrane module.~~