used as separation membranes due to their flexibility and their ease of modification. However, polymeric membranes tend to swell at high temperatures (e.g., > 120 °C) when vapor molecules permeate into the molecular chains. Therefore, such polymer membranes may be unsuitable for prolonged use under harsh conditions in industrial-scale operations.

Membranes based on two-dimensional materials have also been considered in the field of gas/liquid separation. However, to date, efforts to develop membranes using two-dimensional materials have been limited to laboratory-scale research as the stiffness of 2D materials often makes it prohibitive for such membranes to be employed in large-scale industrial operations.

Therefore, there is a need to provide a novel membrane for a separation device that overcomes or at least ameliorates one or more of the drawbacks described above.

Summary of Invention

In one aspect, there is provided a composite membrane comprising at least one two-dimensional material and an inorganic porous material, wherein the inorganic porous material comprises gypsum. Advantageously, the composite membrane described herein demonstrates selectivity for specific gaseous components in a gas/gas, gas/liquid, or liquid/liquid mixture. The selectivity of the composite membrane may be attributed to the intrinsic physicochemical properties of the two-dimensional material, which is dispersed into and/or laminated onto the inorganic porous material, which allows preferential passage of gaseous components having properties that are compatible with the composite membrane.

Further advantageously, the composite membrane described herein selectively separates gaseous components from a gas/gas, gas/liquid, or liquid/ liquid mixture without compromising the mechanical, compression and tensile strength of the composite membrane. The combination of the inorganic porous material and the 2D material demonstrates a compression strength of up to 12.0 MPa, flexural strength of up to 5 MPa and Young's modulus of up to 5,500 GPa, thereby allowing the continuous use of the composite membrane for 2 weeks or more without any decrease in the separation efficiency of the composite membrane.

In another aspect, there is provided a separation device comprising an upper enclosed chamber configured to receive a gaseous component; a lower enclosed chamber in fluid communication with the upper chamber and configured to receive a fluid stream comprising at least one gaseous component, said upper and lower chambers being partitioned by at least one composite membrane, wherein the composite membrane is configured to allow passage of said gaseous component from the lower chamber to the upper chamber, and wherein said

Claims

1. A composite membrane comprising at least one two-dimensional material and an inorganic porous material, wherein the inorganic porous material comprises gypsum.

2. The composite membrane of claim 1, wherein the inorganic porous material is gypsum.

3. The composite membrane of any one of the preceding claims, wherein the 2D material is homogeneously dispersed in the inorganic porous material and/ or is laminated on at least one surface of the inorganic porous material.

4. The composite membrane of any one of the preceding claims, wherein the inorganic porous material is present in an amount from 70 wt.% to 99.9 wt.% based on the total weight of the composite membrane.

5. The composite membrane of any one of the preceding claims, wherein the two-dimensional material is selected from the group consisting of graphene oxide, graphene, graphene nanoplatelets, reduced graphene oxide, molybdenum disulfide, hexagonal boron nitride, phosphorene, transition metal dichalcogenides, xenes, and mixtures thereof.

6. The composite membrane of any one of the preceding claims, wherein the two-dimensional material is selected from graphene oxide, graphene, graphene nanoplatelets, or a mixture thereof.

7. The composite membrane of any one of the preceding claims, wherein the two-dimensional material is present in an amount of from 0.1 wt.% to 20 wt.% based on the total weight of the composite membrane.

8. The composite membrane of any one of the preceding claims, wherein the two-dimensional material is present in an amount of from 0.25 wt.% to 10 wt.% based on the total weight of the composite membrane.

9. The composite membrane of any one of the preceding claims, wherein the composite membrane comprises an average pore size between 0.1 µm to 50 µm.

10. The composite membrane of any one of the preceding claims, wherein the composite membrane comprises an average pore size between 0.5 µm to 10 µm.

11. The composite membrane of any one of the preceding claims, wherein the composite membrane is substantially free of organic matter.

12. A separation device comprising:
an upper enclosed chamber configured to receive a gaseous component;

a lower enclosed chamber in fluid communication with the upper chamber and configured to receive a fluid stream comprising at least one gaseous component,

said upper and lower chambers being partitioned by at least one composite membrane, wherein composite membrane is configured to allow passage of said gaseous component from the lower chamber to the upper chamber, and

wherein said composite membrane of any one of the preceding claims.

13. The separation device of claim 12, wherein the thickness of the composite membrane is 1 mm to 10 mm.

14. The separation device of claims 12-13, wherein the surface area of the composite membrane is 0.001 to 0.6 m^2.

15. The separation device of claims 12-14, wherein the volume of the upper and lower chamber may be, independently, 70 cm^3 to 0.005 m^3.

16. The separation device of claims 12 to 15, wherein the upper chamber further comprises an outlet for discharging the gaseous component; and the lower chamber further comprises an outlet for discharging the fluid stream comprising a reduced amount of the gaseous component.

17. The separation device of claims 12 to 16, wherein the discharged fluid stream is substantially free of the gaseous component.

18. A separation apparatus comprising a plurality of separation devices as defined in any one of claims 12 to 17, wherein said plurality of separation devices may be operated in series or operated to receive a fluid stream from a common feedstock.