The method of the present disclosure comprises inserting a first end of the membrane in a low-viscosity light-curable adhesive having a viscosity less than 5000 cps, removing the first end from the adhesive, and exposing the first end to a light source to cure the adhesive. Use of a low-viscosity light-curable adhesive results in a thin coating of adhesive on the exterior of the first end of the hollow fiber membrane. The low viscosity of the adhesive allows the adhesive to flow into the bore of the membrane. Capillary action further causes the low-viscosity adhesive to wick into the inner wall of the membrane. As a result, a plug is formed in the interior bore that further seals the first end of the membrane.

In one aspect, there is provided a method for sealing the free end of a hollow fiber membrane for use in a single-header filtration module, comprising:

inserting an unsecured first end of said membrane in a low-viscosity light-curable adhesive having a viscosity less than 5000 cps,

removing said unsecured first end from said adhesive,

exposing said unsecured first end to a light source to cure said adhesive, and wherein said unsecured first end of said membrane remains unsecured after sealing.

In another aspect, there is provided a hollow fiber membrane for use in a single-header filtration module, comprising:

a hollow fiber membrane having an interior wall defining a hollow internal bore, an unsecured first end and a second end,

wherein said unsecured first end is coated with a low-viscosity light-curable adhesive,

wherein the thickness of said adhesive coating said first end is less than 0.8 mm; and

wherein said second end is open.

In another aspect, there is provided a hollow fiber filtration module, comprising:

a plurality of hollow fiber membranes, and

one header,

wherein a second end of each of said hollow fiber membranes is secured within said header in a potting compound,

wherein said second end of each hollow fiber membrane is open, and

wherein said first end of each said hollow fiber membrane is unsecured and sealed with a low-viscosity light-curable adhesive.

In another aspect, there is provided a method for sealing a free end of a hollow fiber membrane for use in a single-header filtration module, comprising:

inserting an unsecured first end of said membrane in a low-viscosity light-curable adhesive having a viscosity less than 5000 cps,

removing said unsecured first end from said adhesive whereby a coating of said adhesive is formed on an exterior of said unsecured first end,

after removing said unsecured first end from said adhesive, exposing said unsecured first end to a light source to cure said adhesive,

wherein said coating on the exterior of said unsecured first end after said exposing step has a thickness between 0.05 mm and 0.8 mm; and

securing a plurality of second unsealed ends of membranes in a header such that a density of unsecured sealed first ends of greater than 70 membranes per square inch is achieved.

The present disclosure also encompasses the sealed hollow fiber membrane produced by the process, as well as a hollow fiber filtration module containing fibers sealed by the process of the present disclosure.

Additional aspects of the disclosure, together with the advantages and novel features appurtenant thereto, will be set forth in part in the description which follows, and in part will become apparent to those skilled in the art upon examination of the following, or may be learned from the practice of the invention. The objects and advantages of the discloure may be realized and attained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

Brief Description of the Drawings

Figure 1 is a perspective view of an unsealed hollow fiber membrane.

Figure 2 is a cross-sectional view of a first end of the hollow fiber membrane of Figure 1 after sealing according to the present invention.

Figure 2A is an expanded view of a portion of the hollow fiber membrane of Figure 2 showing penetration of adhesive into the wall of the membrane.

Figure 3 is a cross-sectional view of a first end of the hollow fiber membrane sealed using a high-viscosity adhesive.

Figure 4 is a cross-sectional view of a first end of a hollow fiber membrane being cured after sealing by exposure to a light source.

Figure 5 is a cross-sectional view of a bundle of hollow fiber membranes sealed in accordance with the present invention.

Figure 6 is a cross-sectional view of an exemplary single header filtration module in which the follow fiber membranes have been sealed in accordance with the present invention.

CLAIMS

We claim:

1. A method for sealing the free end of a hollow fiber membrane for use in a single-header filtration module, comprising:

inserting an unsecured first end of said membrane in a low-viscosity light-curable adhesive having a viscosity less than 5000 cps,

removing said unsecured first end from said adhesive,

exposing said unsecured first end to a light source to cure said adhesive, and wherein said unsecured first end of said membrane remains unsecured after sealing.

2. The method of claim 1, wherein said adhesive has a viscosity less than 2000 cps.

3. The method of claim 2, wherein said adhesive has a viscosity between 100 and 1000 cps.

4. The method of claim 3, wherein said adhesive has a viscosity ~~less~~ between 170 and 230 cps.

5. The method of claim 1 wherein the diameter of said first end after said exposing step is less than 4 mm.

6. The method of claim 5 wherein the thickness of said adhesive on said first end after said exposing step is between 0.05 mm and 0.8 mm.

7. The method of claim 1, wherein said inserting step comprises inserting said membrane into said adhesive to immerse a length of 2 - 10 mm of said membrane.

8. The method of claim 1, wherein said exposing step comprises exposing said first end to ultraviolet light.

9. The method of claim 1, wherein said light source has an intensity of at least 200 mW/cm^2.

10. The method of claim 1, wherein said inserting step comprises inserting between two and nine membranes into said adhesive at the same time.

11. The method of claim 1, wherein said inserting step is automated.

12. The method of claim 1, wherein said hollow fiber membrane has not been secured in a header on either end.

13. The method of claim 1 further comprising the step of securing a second unsealed end of said membrane in a header and wherein said method does not comprise the step of inserting said sealed end of said membrane in a header.

14. The method of claim 13 wherein said securing step is performed after said removing step.

15. The method of claim 13 wherein a plurality of said membranes are secured in said header such that a density of greater than 64 membranes per square inch is achieved.

16. A hollow fiber membrane for use in a single-header filtration module, comprising:
a hollow fiber membrane having an interior wall defining a hollow internal bore, an unsecured first end and a second end,
wherein said unsecured first end is coated with a low-viscosity light-curable adhesive,
wherein the thickness of said adhesive coating said first end is less than 0.8 mm; and
wherein said second end is open.

17. The membrane of claim 16, wherein the diameter of said first end coated with said adhesive is less than 4 mm.

18. The membrane of claim 16, further comprising a plug of a low-viscosity light-curable adhesive within said internal bore, wherein said plug extends a length of between 2 and 10 mm.

19. The membrane of claim 18, wherein said first end is coated with said adhesive to a length of between 2 and 10 mm from said first end.

20. The membrane of claim 18, wherein said adhesive extends into said interior wall integrally to said plug.

21. A hollow fiber filtration module, comprising:
a plurality of hollow fiber membranes, and
one header,
wherein a second end of each of said hollow fiber membranes is secured within said header in a potting compound,

wherein said second end of each hollow fiber membrane is open, and

wherein said first end of each said hollow fiber membrane is unsecured and sealed with a low-viscosity light-curable adhesive.

22. The module of claim 21, wherein the diameter of the sealed first end is less than 4 mm.

23. A method for sealing a free end of a hollow fiber membrane for use in a single-header filtration module, comprising:

inserting an unsecured first end of said membrane in a low-viscosity light-curable adhesive having a viscosity less than 5000 cps,

removing said unsecured first end from said adhesive whereby a coating of said adhesive is formed on an exterior of said unsecured first end,

after removing said unsecured first end from said adhesive, exposing said unsecured first end to a light source to cure said adhesive,

wherein said coating on the exterior of said unsecured first end after said exposing step has a thickness between 0.05 mm and 0.8 mm; and

securing a plurality of second unsealed ends of membranes in a header such that a density of unsecured sealed first ends of greater than 70 membranes per square inch is achieved.

24. The method of claim 23, wherein said hollow fiber membranes have a nominal diameter of approximately 2.5 mm.

25. The method of claim 23, wherein the density of the unsecured sealed first ends achieved is greater than 81 membranes per square inch.

26. The method of claim 23, wherein the plurality of second unsealed ends of membranes in the header is secured such that a ratio of the number of sealed first ends per square inch to the diameter of an individual membrane in inches is at least 714.