FLEXIBLE TUBE

BACKGROUND OF THE INVENTION

The invention relates to a flexible tube and a method of manufacturing same, and more particularly, to a flexible tube having a reduced radius of curvature, a high bending capability and a gas tightness which may be used in forming a forceps channel, or a gas or water feed channel of an endoscope used for medical purposes, and a method of manufacturing same.

A medical endoscope which is used to provide an observation of coeloma of a living body or a treatment of an affected part therein is constructed in a manner as illustrated in FIG. **1**, which shows an endoscope of a direct view type. Specifically, endoscope **1** includes an operating end **2** which is connected with a flexible tube which defines portion **3** of the endoscope which is adapted to be inserted into coeloma. The operating end **2** is located outside a physical body and is subject to a variety of manual operations. The operating end **2** is provided with a number of accessories including bend operator **5** which is used to bend the free end of the endoscope portion **3** in a desired direction, an observation eyepiece assembly **6**, forceps receiver **7** which is utilized to insert forceps into forceps channel **9** formed by flexible tube **10** (see FIG. **2**), and fittings **8** which are used to feed a gas or water into gas/water feed channel **13** (see FIG. **2**) also formed by a flexible tube.

The free end of the endoscope portion **3** is fixedly provided with end fixture **4** which includes a channel opening, an illumination and an observation window. Referring to FIG. **2**, end fixture **4** has front end face **4*a*** in which illumination window **11** and observation window **12** are located symmetrically with respect to the center line thereof for enabling an illumination and an observation of a desired area within coeloma. Also formed in the end face **4*a*** are opening **9*a*** associated with forceps channel **9** and opening **13*a*** associated with gas/water feed channel **13** above and below these windows, respectively.

An objective lens, not shown, is disposed inside observation window **12** in opposing relationship therewith, and constitutes an observation optical system together with an eyepiece, not shown, located within the eyepiece assembly **6** and a flexible image guide formed by a bundle of optical fibres which extend between the both lenses to conduct light therebetween.

One end face of a light guide, not shown, which is constructed in a conventional manner, is located inside illumination window **11** in opposing relationship therewith while the other end face of the light guide is located within the operating end **2** in opposing relationship with an illumination light emitting port of a light source disposed therein, whereby light from the source is directed through the light guide and illumination window **11** to irradiate a desired area within coeloma which is to be observed.

The flexible tube which forms the endoscope portion **3** to be inserted into coeloma has a very small radius of curvature in its region **3*a*** which is subject to an increased degree of bending, and in a corresponding manner, flexible tubes such as tube **10** which defines forceps channel **9** also have a reduced radius of curvature. In addition to high degree of bending capability, gas and water tightness is required of these flexible tubes such as tube **10** in order to prevent an ingress of coeliac fluid into the flexible tubes because their front ends are open into the coeloma. Furthermore, they should be free from kinks, crushing, wrinkles in the tube walls and should have a smooth internal wall surface.

However, there is known no conventional tubes of this kind which are free from kinks, crushing or surface wrinkles when they are bent into a diameter which is as small as ten times the diameter (R) of the tubes themselves. If the tubes are free from kinks or crushing when bent to a diameter of 10R, a greater force is required during their manufacturing or a special treatment such as the application of heat or pressure is required in order to bend these tubes into such diameters. Although a multi-layer tube is known in the prior art, the purpose of the lamination is to improve the pressure resistance of the tube, and is not directed to an improvement of the bending capability, flexibility, or the freedom from kinks when bent into small radii. In short, there is no flexible tube having a gas and water tightness and which is adapted to be used in the manner mentioned above, and therefore it will be appreciated that there has been a strong need for the provision of such flexible tube.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a flexible tube which satisfy the described requirements, by providing a tubular body formed of a crystalline polymer material having porous microstructures including a number of micro-nodes which are coupled together by fibrils and in which the pores in the microstructures are filled with a gas tight and stretchable plastic material, and a method of manufacturing same.

In accordance with the invention, there is provided a flexible tube which has improved performances over conventional flexible tube, and which can be manufactured in a simple and inexpensive manner.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a front view of an endoscope of a direct view type incorporating flexible tubes to define forceps channel and gas/water feed channel;

FIG. **2** is an enlarged end view of a front end face of a portion of the endoscope shown in FIG. **1** which is adapted to be inserted into coeloma;

FIG. **3** is an enlarged illustration of porous microstructures of a crystalline polymer material; and

FIG. **4** is a cross section illustrating one step of a method of manufacturing a flexible tube in accordance with the invention.

DESCRIPTION OF PREFERRED EMBODIMENT

A flexible tube which is manufactured in accordance with the invention utilizes a tubular body formed of a crystalline polymer material having porous microstructures which include a number of micro-nodes coupled together by fibrils. Preferred crystalline polymer materials include fluorine resins and polyolefins. Specific examples of fluorine resins include polytetrafluoroethylene (PTFE) to which may or may not be added an extractable inorganic additive such as silicate, carbonate, metal, metal oxide, sodium chloride, ammonium chloride or the like, or an organic powder such as a powder of a copolymer of tetrafluoroethylene and hexafluoropropylene (FEP), starch, sugar or the like. A specific example of polyolefins includes a polypropylene resin.

FIG. **3** is an enlarged perspective view showing part of porous microstructures of PTFE where a number of