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Courier Press, Leamington Spa, England.

Description

This invention relates to a method of assembling an electrolytic cell and in particular to a method of installing an ion-exchange member in an electrolytic cell.

Electrolytic cells are known comprising a plurality of anodes and cathodes with each anode being separated from the adjacent cathode by an ion-exchange membrane which divides the electrolytic cell into a plurality of anode and cathode compartments. The anode compartments of such a cell are provided with means for feeding electrolyte to the cell, suitably from a common header, and with means for removing products of electrolysis from the cell. Similarly, the cathode compartments of the cell are provided with means for removing products of electrolysis from the cell, and optionally with means for feeding water or other fluid to the cell. The electrolytic cells may be of the monopolar or bipolar type.

For example electrolytic cells of the filter press type may comprise a large number of alternating anodes and cathodes, for example, fifty anodes alternating with fifty cathodes, although the cell may comprise even more anodes and cathodes, for example up to one hundred and fifty alternating anodes and cathodes.

In such an electrolytic cell the membranes are essentially hydraulically impermeable and in use ionic species, e.g. hydrated ionic species, are transported across the membrane between the anode and cathode compartments of the cell. Thus, when an aqueous alkali metal chloride solution is electrolysed in a cell equipped with cation-exchange membranes the solution is fed to the anode compartments of the cell and chlorine produced in the electrolysis and depleted alkali metal chloride solution are removed from the anode compartments, alkali metal ions are transported across the membranes to the cathode compartments of the cell to which water or dilute alkali metal hydroxide solution may be fed, and hydrogen and alkali metal hydroxide solution produced by the reaction of alkali metal ions with hydroxyl ions are removed from the cathode compartments of the cell.

Electrolytic cells of the type described may be used particularly in the production of chlorine and sodium hydroxide by the electrolysis of aqueous sodium chloride solution.

In such an electrolytic cell the membrane is secured to the cell, for example, by clamping between gaskets. It is desirable that the membrane be installed in the cell in a taut state and that the membrane remain in a substantially taut state when electrolyte is charged to the cell and the cell is operated. However, if a membrane is installed in an electrolytic cell in a dry state and is fixed tautly therein it is found that in use when electrolyte is contacted with the membrane in the cell the membrane swells and expands and becomes slack and may even become wrinkled. As a result there may be uneven release of gas and an increase in the voltage of the cell. This is a

particular disadvantage where the cell is designed to operate at low, or zero, anode-cathode gap.

In order to alleviate this problem of swelling of the membrane in use it has been proposed to pre-swelling the membrane before installing the membrane in an electrolytic cell, for example by soaking the membrane in water, in an aqueous sodium chloride solution, or in an aqueous sodium hydroxide solution. Ideally, the membrane should be pre-swelled to an extent approximately the same as that by which a dry membrane would be swelled by contact with the electrolyte in the electrolytic cell.

In US Patent No. 4000057 there is described the pre-swelling of a membrane before installation of the membrane in an electrolytic cell the method comprising contacting the membrane with a liquid medium in which the membrane exhibits a substantially flat expansion versus time curve for at least four hours after contacting the membrane with the liquid medium. Suitable liquid media include, for example, aqueous solutions of ethylene glycol, glycerine and higher fatty alcohols.

Although the aforementioned methods do assist in overcoming the problem of swelling of a membrane when the membrane is contacted with electrolyte in an electrolytic cell they do themselves suffer from substantial disadvantages. Thus, the pre-swelled membranes are wet and remain wet during installation in the electrolytic cell and are thus difficult to handle. Special handling precautions may need to be taken, for example where the membrane has been pre-swelled by contact with a corrosive liquid, e.g. a caustic soda solution. Also difficulty may also be experienced in securing the wet membrane in the electrolytic cell in a leak-tight manner, for example between a pair of gaskets.

In US Patent No. 4124477 there is described immersing a membrane in boiling water for 1 to 4 hours, placing the membrane on a frame having the approximate dimensions of an anode on which the membrane is to be mounted, stretching the membrane diagonally and clamping it at the corners of the frame, and stretching the sides of the membrane and clamping them to the sides of the frame.

The present invention relates to a method of assembling an electrolytic cell and installing an ion-exchange membrane in an electrolytic cell which does not suffer from the aforementioned disadvantages.

According to the present invention there is provided a method of assembling an electrolytic cell which comprises expanding an ion-exchange membrane comprising an organic polymer containing ion-exchange groups or derivatives thereof convertible to ion-exchange groups and securing the expanded membrane to the electrolytic cell or to a part thereof characterised in that a pre-formed membrane is expanded by stretching the membrane to increase the surface area per unit weight of the membrane by at least 20% and that thereafter the expanded, stretched

membrane is secured to the electrolytic cell or to a part thereof.

In the method of the invention the pre-formed ion-exchange membrane, e.g. in the form of a sheet or film is expanded by stretching so as to increase the surface area of the membrane per unit weight of membrane.

This expansion of the membrane does not depend on the use of a liquid medium to swell and thus expand the membrane. Indeed, the expansion by stretching will generally be effected, and is preferably effected, on a dry membrane, thus avoiding the substantial disadvantages associated with use of a liquid medium. Furthermore, the expansion is not effected merely by pressing the membrane at elevated pressure and temperature.

The stretching of the membrane should be effected with care in order not to tear the membrane. The use of elevated temperature during the stretching of the membrane greatly assists in avoiding tearing of the membrane. The elevated temperature may be greater than 40°C, or greater than 55°C.

In operating the method of the invention the pre-formed membrane may be heated to an elevated temperature and the membrane expanded by stretching the membrane at the elevated temperature, and the thus expanded, stretched membrane may be secured to the electrolytic cell or a part thereof.

It is further preferred to stretch the membrane at elevated temperature and to cool the membrane to a lower temperature, e.g. to a temperature at or near ambient, whilst restraining the membrane in the expanded, stretched state, and thereafter to secure the expanded, stretched membrane to the electrolytic cell or to a part thereof.

The stretching may be effected, for example, by passing the membrane around and between rollers operating at different peripheral speeds, and the expanded, stretched membrane may be cooled to a lower temperature. Alternatively, the membrane may be expanded by applying a stretching force to opposed edges of the membrane. The stretching of the membrane may be effected in a stretching frame or machine.

The membrane may be stretched uniaxially or biaxially. Biaxial stretching may be effected in two directions simultaneously or sequentially.

When the membrane is stretched uniaxially strips of a relatively stiff material may be attached to opposed edges of the membrane to prevent contraction of the membrane in a direction transverse to that in which the membrane is stretched.

Where the membrane is stretched, e.g. at elevated temperature, and particularly where the membrane is subsequently cooled to a lower temperature, for example, at or near ambient temperature, e.g. whilst the membrane is restrained in the expanded, stretched state, at least some of the expansion of the membrane effected by stretching is "locked" into the membrane. When the expanded, stretched membrane

is installed in an electrolytic cell and secured therein and the membrane is contacted with an electrolyte, particularly at an elevated temperature, for example with aqueous alkali metal chloride solution at a temperature, which may be as high as 95°C in a chlor-alkali cell, the expansion which is "locked" into the membrane is released, or partially released, and the membrane tends to contact towards its original state, although the membrane is of course restrained in the electrolytic cell. This tendency to contact is counteracted by the expansion of the membrane caused by swelling brought about by contacting the membrane with the electrolyte, with the result that the membrane installed in the electrolytic cell remains taut and does not become wrinkled during use.

It is preferred that the amount of expansion effected by stretching should be approximately the same as or greater than the expansion caused by swelling of the membrane on contact with the electrolyte in the electrolytic cell so that the membrane, when contracted with the electrolyte, remains taut in the cell. Some benefit will however be obtained even if the amount of expansion to be effected by stretching is somewhat less than expansion caused by swelling of the membrane on contact with the electrolyte. A suitable amount of expansion to be effected by stretching may be determined by simple test.

Expansion of the membrane effected by stretching should produce an increase of at least 20% in the surface area of the membrane per unit weight of membrane. A larger expansion of the membrane may be effected by stretching, for example an increase of at least 50% or at least 100% in the surface area per unit weight of the membrane, or even a 10-fold increase or greater in the surface area per unit weight of the membrane. Where a substantial amount of stretching is effected additional benefits will be obtained. Thus, where a large expansion of the membrane has been effected by stretching use of the membrane in an electrolytic cell will result in a lower voltage of operation, with consequent savings in power costs. Additionally, the products of electrolysis may be produced at a higher current efficiency.

In order that the bulk of the expansion of the membrane effected by stretching may be "locked" into the membrane the membrane may be cooled from an elevated temperature to a lower temperature whilst the membrane is restrained in the expanded, stretched state. However, when such a membrane is used in an electrolytic cell the contraction of the membrane which occurs when the membrane is contacted with electrolyte at elevated temperature may be much greater than the expansion caused by swelling of the membrane by contact with electrolyte, and the membrane may tend to tear. Whether or not there is any tendency to tear will of course depend on the extent of the expansion of the membrane effected by stretching.

It is preferred, where the extent of expansion of

the membrane which is effected by stretching is substantial, and in order for example to produce a membrane which has a much increased surface area per unit per weight and which thus is capable of operating at a substantially reduced voltage in an electrolytic cell, for the membrane to be expanded by stretching at an elevated temperature and for the expanded, stretched membrane to be annealed by heating at the elevated temperature, and subsequently to cool the membrane to a lower temperature. In this way sufficient expansion may be "locked" into the membrane for the membrane to remain taut and unwrinkled during use in an electrolytic cell and also for any tendency for the membrane to tear during use to be overcome.

The membrane which is subjected to expansion by stretching will generally be in the form of a film and may, for example, have a thickness in the range 0.2 to 2 mm.

Although extremely thin membranes may be produced by stretching the expanded, stretched membrane should not be so thin that it is highly susceptible to damage when used in an electrolytic cell. In general the expanded, stretched membrane will have a thickness of at least 0.02 mm, preferably at least 0.1 mm.

The elevated temperature at which stretching of the membrane may be effected will depend on the nature of the membrane. It will in general, however, be in excess of 40°C, preferably in excess of 55°C. A suitable temperature for use with a particular membrane may be selected by simple experiment. The temperature should not be so high that the organic polymer of the membrane melts or is degraded to a significant extent. In general the elevated temperature at which stretching is effected will not be above 150°C.

Where the expanded, stretched membrane is annealed the annealing temperature may be the same as or similar to the elevated temperature at which the membrane is stretched. The annealing temperature may be higher than the temperature at which stretching is effected. The time for which the expanded, stretched membrane is annealed will determine the extent of the expansion of the membrane which is "locked" into the membrane when the membrane is subsequently cooled to a lower temperature, the longer is this annealing time the less will be the extent of the expansion which remains "locked" into the membranes. In general, the annealing time will be at least 1 minute, but in general it will not be more than 5 hours.

The lower temperature to which the membrane may be cooled will be a temperature at which the membrane does not relax rapidly when the restraining force, if any is removed from the membrane. It is most convenient to cool the membrane to a temperature which is at or near ambient temperature.

In a further preferred embodiment, particularly useful where the membrane is to be expanded to a substantial extent by stretching, the membrane

is stretched at elevated temperature, the membrane is cooled to a lower temperature, e.g. to a temperature at or near ambient, whilst restraining the membrane in the expanded stretched state, and the steps of expansion by stretching at elevated temperature and cooling are repeated at least once. In this way the desired amount of expansion of the membrane may be effected by stretching in a plurality of stages and there is a decreased possibility of the membrane being damaged, e.g. by tearing, during the stretching.

The ion-exchange membrane is preferably a cation-exchange membrane containing acidic groups or derivatives thereof convertible to acidic groups. In order to provide resistance to the corrosive environment encountered in many electrolytic cells, particularly in chlor-alkali cells, the membrane is preferably a fluoropolymer, and more preferably a perfluoropolymer, containing such acidic groups or derivatives thereof.

Suitable acidic groups include sulphonic acid, carboxylic acid or phosphonic acid. The membrane may contain two or more different acidic groups. Suitable derivatives of the acidic groups include salts of such groups, for example metal salts, such groups, particularly alkali metal salts. Suitable derivatives include in particular derivatives convertible to acidic groups by hydrolysis, for example acidic halide groups, e.g. $-\text{SO}_2\text{F}$ and $-\text{COF}$, nitrile groups $-\text{CN}$, acid amide groups $-\text{CONR}_2$, where R is H or alkyl, and acid ester groups, e.g. $-\text{COOR}$, where R is an alkyl group.

Suitable cation-exchange membranes are those described, for example, in the GB Patents Nos. 1184321, 1402920, 1406673, 1455070, 1497748, 1497749, 1518387 and 1531068.

It is preferred to use membranes containing derivatives of acidic groups which are convertible to ion-exchange groups by hydrolysis as membranes containing such groups are generally more susceptible to stretching. For example, where the membrane is a fluoropolymer containing carboxylic acid groups as ion-exchange groups it is preferred to stretch the membrane in a form in which the carboxylic groups are in the ester form, e.g. in the form of a methyl ester.

Where the membrane contains groups convertible to ion-exchange groups by hydrolysis the hydrolysis may be effected, for example, by contacting the membrane with aqueous alkali metal hydroxide solution, e.g. with aqueous sodium hydroxide solution. As the membrane may tend to swell on hydrolysis it is preferred to effect such hydrolysis after the expanded, stretched membrane has been secured to the electrolytic cell or to a part thereof.

The membrane may be reinforced, for example with a net of fluoropolymer, although such reinforced membranes are not preferred as difficulty may be experienced in stretching the reinforcing net. The membrane may be in the form of a laminate, or it may be coated with electrode or non-electrode materials.

The expanded, stretched ion-exchange membrane is secured in the electrolytic cell, or to a part

of the electrolytic cell. Where the membrane has been expanded by stretching at elevated temperature it may be secured in the electrolytic cell or to a part thereof whilst at the elevated temperature. However, as the expanded stretched membrane will tend to cool toward ambient temperature and thus contract during this securing procedure it is preferred to lock the expansion into the membrane prior to securing the membrane into the electrolytic cell or to a part thereof. Thus, it is preferred to expand the ion-exchange membrane by stretching at elevated temperature and to restrain the membrane in the expanded, stretched state whilst cooling the membrane to a lower temperature, and preferably to ambient temperature, at which temperature the membrane remains a substantial proportion of its expanded stretched state when the restraining force is removed.

The expanded stretched membrane may be secured to the electrolytic cell or to a part thereof by any convenient means. For example, the membrane may be securely clamped between a pair of gaskets in the electrolytic cell, or the membrane may be secured to a frame which is subsequently installed in the electrolytic cell, or the membrane may be secured to an electrode.

The method of the present invention is particularly suitable for use in assembling an electrolytic cell of the filter press type. Electrolytic cells of the filter press type may comprise a large number of alternating anodes and cathodes with an ion-exchange membrane positioned between each anode and adjacent cathode. Such cells may comprise, for example, fifty anodes alternating with fifty cathodes, although the cell may comprise even more anodes and cathodes, for example up to one hundred and fifty alternating anodes and cathodes.

In the electrolytic cell the electrodes will generally be made of a metal or alloy. The nature of the metal or alloy will depend on whether the electrode is to be used as an anode or cathode and on the nature of the electrolytic cell.

Where aqueous alkali metal chloride solution is to be electrolysed and the electrode is to be used as an anode the electrode is suitably made of a film-forming metal or an alloy thereof, for example of zirconium, niobium, tungsten or tantalum, but preferably of titanium, and the surface of the anode suitably carries a coating of an electro-conducting electrocatalytically active material. The coating may comprise one or more platinum group metals, that is platinum, rhodium, iridium, ruthenium, osmium or palladium, and/or an oxide of one or more of these metals. The coating of platinum group metal and/or oxide may be present in admixture with one or more non-noble metal oxides, particularly one or more film-forming metal oxides, e.g. titanium dioxide.

Electro-conducting electrocatalytically active materials for use as anode coatings in an electrolytic cell for the electrolysis of aqueous alkali metal chloride solution, and methods of application of such coatings, are well known in the art.

Where aqueous alkali metal chloride solution is to be electrolysed and the electrode is to be used as a cathode the electrode is suitably made of iron or steel, or of other suitable metal, for example nickel. The cathode may be coated with a material designed to reduce the hydrogen overpotential of the electrolysis.

Any suitable construction of electrode may be used in the electrolytic cell. For example the electrode may comprise a plurality of elongated members, e.g. rods or strips, or it may comprise a foraminated surface, e.g. a perforated plate, a mesh, or an expanded metal.

The invention is illustrated by the following examples.

Example 1

A rectangular section 35 cm $\times$ 30 cm was cut from a 280 micron thick sheet of a cation-exchange membrane of a copolymer of tetrafluoroethylene and a perfluorovinyl ether containing carboxylic acid groups, the ion-exchange capacity of the membrane being 1.3 milli equivalents per gram.

Strips of PVC elastic tape were attached to the sheet at each of the 35 cm long edges of the sheet and strips of aluminium were attached to the sheet at each of the 30 cm long edges of the sheet. The sheet was then mounted in a Bruckner Karo 11 orienter and the temperature of the sheet was raised to 67°C in an oven associated with the orienter.

The aluminium strips were pulled apart at a rate of 1 metre per minute until the spacing of the aluminium strips attached to the sheet had increased by a factor of 1.5, the PVC elastic strips assisting in the prevention of "waisting" of the sheet. The sheet, whilst mounted on the orienter, was then removed from the oven and cooled to ambient temperature in a stream of air.

The above procedure of stretching the sheet at a temperature of 67°C and cooling of the sheet to ambient temperature was repeated twice, in the first repeat of the procedure the spacing of the aluminium strips being increased by a factor of 2.5 over the original spacing and in the second repeat of the procedure the spacing of the aluminium strips being increased by a factor of 4.2 over the original spacing.

The resultant cation-exchange membrane film was then removed from the orienter. The film relaxed slightly towards the original dimensions of the sheet. The thickness of the film after this slight relaxation was 80 microns.

The film of cation-exchange membrane produced as described above was securely and tautly clamped between a pair of gaskets of EPDM rubber and mounted in an electrolytic cell equipped with a 7.5 cm diameter nickel mesh cathode and a 7.5 cm diameter titanium mesh anode coated with a coating of a mixture of RuO₂ and TiO₂ in a proportion of 35 RuO₂: 65 TiO₂ by weight.

310 g/l aqueous NaCl solution at a pH of 8.0 was charged to the anode compartment of the cell and

water was charged to the anode compartment of the cell and water was charged to the cathode compartment of the cell and the NaCl was electrolysed therein at a temperature of 90°C, the concentration of NaCl in the anode compartment during electrolysis being 200 g/l.

Chlorine and depleted NaCl solution were removed from the anode compartment and hydrogen and aqueous NaOH (35% by weight) were removed from the cathode compartment.

The electrolysis was effected at a current density of 1kA/m² and the cell voltage was 3.01 volts.

After a total of 20 days electrolysis the cell was opened and the cation-exchange membrane examined. The membrane was found to be taut and not wrinkled.

By way of comparison the above electrolysis procedure was repeated except that a 280 micron thick sheet of cation-exchange membrane was installed in the electrolytic cell, that is a membrane which had not been subjected to the stretching process.

At a current density of 1kA/m² the voltage was 3.1 volts and the membrane removed from the cell was found to be wrinkled and no longer taut.

Example 2

The electrolysis procedure of Example 1 was repeated at a current density of 2kA/m². In this case the voltage was 3.24 volts and, as in the case of Example 1 the membrane, when removed from the cell, was found to be taut and unwrinkled.

By way of comparison the above electrolysis procedure was repeated except that a 280 micron thick sheet of cation-exchange membrane was installed in the electrolytic cell, that is a membrane which had not been subjected to the stretching process.

At a current density of 2 kA/m² the voltage was 3.4 volts and the membrane removed from the cell was found to be wrinkled and no longer taut.

Example 3

The electrolysis procedure of Example 1 was repeated at a current density of 3 kA/m². In this case the voltage was 3.52 volts and, as in the case of Example 1, the membrane, when removed from the cell, was found to be taut and unwrinkled.

By way of comparison the above electrolysis procedure was repeated except that a 280 micron thick sheet of cation-exchange membrane was installed in the electrolytic cell, that is a membrane which had not been subjected to the stretching process.

At a current density of 3 kA/m² the voltage was 3.7 volts and the membrane removed from the cell was found to be wrinkled and no longer taut.

Example 4

A sample of a cation-exchange membrane of a copolymer of tetra-fluoroethylene and a perfluorovinyl ether containing sulphonic acid groups in the form of the potassium salt of dimensions 11.5 cm × 11.5 cm was taped at its

edges with PVC tape and the thus taped membrane was clamped in a stentor frame. The membrane was heated to a temperature of 180°C and was drawn uniaxially at a draw speed of 0.85 m/min until the membrane had been drawn by a factor of 2.0. The membrane was then cooled to ambient temperature and removed from the stentor frame.

The membrane was installed in an electrolytic cell as described in Example 1 and the electrolysis procedure of Example 2 was followed, that is aqueous NaCl solution was electrolysed at a current density of 2 kA/m². NaOH solution at a concentration of 25% by weight was produced at a current efficiency of 50%. The cell voltage was 2.95 volts.

When the electrolytic cell was opened the membrane was found to be taut and unwrinkled.

By way of comparison the electrolysis procedure was repeated except that there was used a membrane as described above which had not been subjected to the stretching procedure. The cell operated at a voltage of 3.1 volts and NaOH was produced at a current efficiency of 57%.

When the cell was opened the membrane was found to be wrinkled and no longer taut.

Example 5

The stretching procedure of Example 4 was repeated except that the membrane which was used was a copolymer of tetrafluoroethylene and a perfluorovinyl ether containing carboxylic acid methyl ester groups, and the temperature to which the membrane was heated during the stretching was 80°C.

The membrane was installed in an electrolytic cell as described in Example 1, hydrolysed by contact with NaOH solution, and the electrolysis procedure of Example 3 was followed, that is aqueous NaCl solution was electrolysed at a current density of 3 kA/m². NaOH solution at a concentration of 35% by weight was produced at a current efficiency of 94%. The cell voltage was 3.32 volts.

When the electrolytic cell was opened the membrane was found to be taut and unwrinkled.

By way of comparison the electrolysis procedure was repeated except that there was used a membrane as described above which had not been subjected to the stretching procedure. The cell operated at a voltage of 3.4 volts and NaOH was produced at a current efficiency of 94%.

When the cell was opened the membrane was found to be wrinkled and no longer taut.

Example 6

A sample of an ion-exchange membrane of a copolymer of tetrafluoroethylene and perfluorovinyl ether containing carboxylic acid methyl ester groups as used in Example 5 was heated at a temperature of 67°C and was stretched uniaxially on a stentor frame following the procedure described in Example 4, except that the draw rate was 1 m/min and the membrane was stretched by a factor of 4.3, that is it was

stretched to 430% of its original length in the direction of stretch. After completion of the stretching the membrane was cooled rapidly to ambient temperature in a stream of air and removed from the frame.

After standing for 15 minutes the membrane was found to have shrunk by 15% in the direction of stretching, so that in this direction it was 365% of its original length in this direction.

The electrolysis procedure of Example 1 was repeated using the above described membrane. After effecting electrolysis for 20 days the membrane was found to be taught and unwrinkled.

Example 7 to 9

The procedure of Example 6 was repeated on three separate samples of membrane except that, prior to cooling and removal from the stentor frame, the samples were annealed after completion of the stretching by heating at 67°C for respectively 1 minute (Example 7), 2 minutes (Example 8) and 3 minutes (Example 9).

After standing for 15 minutes after removal from the frame the membranes were found to have shrunk, in the direction of stretching, respectively by 11% (Example 7), 10% (Example 8), and 9% (Example 9), that is in this direction the membranes were 383% (Example 7), 387% (Example 8), 391% (Example 9) of their original length.

The electrolysis procedure of Example 1 was repeated using each of the above described membranes. After effecting electrolysis for 20 days each of the membranes was found to be taut and unwrinkled.

Claims

1. A method of assembling an electrolytic cell which comprises expanding an ion-exchange membrane comprising an organic polymer containing ion-exchange groups or derivatives thereof convertible to ion-exchange groups and securing the expanded membrane to the electrolytic cell or to a part thereof, characterised in that a pre-formed membrane is expanded by stretching the membrane to increase the surface area per unit weight of the membrane by at least 20% and that thereafter the expanded, stretched membrane is secured to the electrolytic cell or to a part thereof.

2. A method as claimed in Claim 1 characterised in that the membrane is expanded by stretching at an elevated temperature of greater than 40°C.

3. A method as claimed in Claim 2 characterised in that the membrane is expanded by stretching at an elevated temperature of greater than 40°C, the expanded, stretched membrane is cooled to a lower temperature whilst restraining the membrane in an expanded, stretched state, and thereafter the membrane is secured to the electrolytic cell or to a part thereof.

4. A method as claimed in any one of Claims 1 to 3 characterised in that the membrane is expanded by stretching the membrane uniaxially.

5. A method as claimed in any of the Claims 1 to 3 characterised in that the membrane is expanded by stretching the membrane biaxially.

6. A method as claimed in any one of Claims 1 to 5 characterised in that the membrane is expanded by stretching to increase the surface area per unit weight of the membrane by at least 50%.

7. A method as claimed in Claim 6 characterised in that the membrane is expanded by stretching to increase the surface area per unit weight of the membrane by at least 100%.

8. A method as claimed in any one of Claims 1 to 7 characterised in that the membrane is expanded by stretching at a temperature of at least 55°C.

9. A method as claimed in Claim 8 characterised in that the membrane is annealed by heating the expanded, stretched membrane at a temperature of at least 55°C.

10. A method as claimed in any one of Claims 1 to 9 characterised in that the membrane is expanded by stretching at elevated temperature and the membrane is cooled to a lower temperature whilst restraining the membrane in the expanded, stretched state, and the steps of expanding by stretching and cooling are repeated at least once each.

11. A method as claimed in any one of Claims 1 to 10 characterised in that the membrane comprises a fluoropolymer.

12. A method as claimed in any one of Claims 1 to 11 characterised in that the ion-exchange groups are sulphonic acid and/or carboxylic acid groups, or groups convertible thereto.

13. A method as claimed in Claim 12 characterised in that the ion-exchange groups are carboxylic acid ester groups.

14. A method as claimed in any one of Claims 1 to 13 characterised in that the pre-formed membrane has a thickness in the range of 0.2 to 2 mm.

15. A method as claimed in any one of Claims 1 to 14 characterised in that the expanded, stretched membrane has a thickness of at least 0.02 mm.

Patentansprüche

1. Verfahren zum Zusammenbau einer elektrolytischen Zelle, bei welchem eine Ionenaustauschmembrane aus einem organischen Polymer, das Ionenaustauschgruppen oder in Ionenaustauschgruppen umwandelbare Derivate davon enthält, expandiert wird und die expandierte Membrane in der elektrolytischen Zelle oder auf einem Teil derselben befestigt wird, dadurch gekennzeichnet, daß eine vorher hergestellte Membrane durch Strecken derart expandiert wird, daß die Oberfläche je Gewichtseinheit der Membrane um mindestens 20% zunimmt, und daß hierauf die expandierte, gestreckte Membrane in der elektrolytischen Zelle oder auf einem Teil derselben befestigt wird.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß die Membrane durch Strecken bei

einer erhöhten Temperatur von mehr als 40°C expandiert wird.

3. Verfahren nach Anspruch 2, dadurch gekennzeichnet, daß die Membrane durch Strecken bei einer erhöhten Temperatur von mehr als 40°C expandiert wird, die expandierte, gestreckte Membrane auf eine niedrigere Temperatur abgekühlt wird, während sie in einem expandierten, gestreckten Zustand gehalten wird, und hierauf die Membrane in der elektrolytischen Zelle oder auf einem Teil derselben befestigt wird.

4. Verfahren nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß die Membrane durch uniaxiales Strecken der Membrane expandiert wird.

5. Verfahren nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß die Membrane durch biaxiales Strecken der Membrane expandiert wird.

6. Verfahren nach einem der Ansprüche 1 bis 5, dadurch gekennzeichnet, daß die Membrane durch Strecken derart expandiert wird, daß die Oberfläche je Gewichtseinheit der Membrane um mindestens 50% zunimmt.

7. Verfahren nach Anspruch 6, dadurch gekennzeichnet, daß die Membrane durch Strecken derart expandiert wird, daß die Oberfläche je Gewichtseinheit der Membrane um mindestens 100% zunimmt.

8. Verfahren nach einem der Ansprüche 1 bis 7, dadurch gekennzeichnet, daß die Membrane durch Strecken bei einer Temperatur von mindestens 55°C expandiert wird.

9. Verfahren nach Anspruch 8, dadurch gekennzeichnet, daß die Membrane durch Erhitzen der expandierten, gestreckten Membrane auf eine Temperatur von mindestens 55°C getempert wird.

10. Verfahren nach einem der Ansprüche 1 bis 9, dadurch gekennzeichnet, daß die Membrane durch Strecken bei einer erhöhten Temperatur expandiert wird und die Membrane auf eine niedrigere Temperatur abgekühlt wird, während sie in einem expandierten, gestreckten Zustand gehalten wird, wobei die Stufen des Expandierens durch Strecken und des Abkühlens mindestens jeweils einmal wiederholt werden.

11. Verfahren nach einem der Ansprüche 1 bis 10, dadurch gekennzeichnet, daß die Membrane ein Fluoropolymer enthält.

12. Verfahren nach einem der Ansprüche 1 bis 11, dadurch gekennzeichnet, daß die Ionenaustauschgruppen Sulfonsäure- und/oder Carbonsäure-Gruppen oder in solche Gruppen umwandelbar Gruppen sind.

13. Verfahren nach Anspruch 12, dadurch gekennzeichnet, daß die Ionenaustauschgruppen Carbonsäureester-Gruppen sind.

14. Verfahren nach einem der Ansprüche 1 bis 13, dadurch gekennzeichnet, daß die vorher hergestellte Membrane eine Dicke im Bereich von 0,2 bis 2 mm aufweist.

15. Verfahren nach einem der Ansprüche 1 bis 14, dadurch gekennzeichnet, daß die expandierte, gestreckte Membrane eine Dicke von mindestens 0,02 mm aufweist.

Revendications

1. Procédé pour assembler une cellule électrolytique, qui comprend la dilatation d'une membrane échangeuse d'ions comprenant un polymère organique contenant des radicaux échangeurs d'ions ou des dérivés de ceux-ci convertibles en radicaux échangeurs d'ions, et la fixation de la membrane dilatée à la cellule électrolytique ou à un organe de celle-ci, caractérisé en ce qu'une membrane formée au préalable est dilatée par étirage de la membrane aux fins d'augmenter la surface par unité de poids de la membrane d'au moins 20% et que la membrane dilatée et étirée est ensuite fixée à la cellule électrolytique ou à un organe de celle-ci.

2. Procédé suivant la revendication 1, caractérisé en ce que la membrane est dilatée par étirage à une température élevée supérieure à 40°C.

3. Procédé suivant la revendication 2, caractérisé en ce que la membrane est dilatée par étirage à une température élevée supérieure à 40°C, la membrane dilatée et étirée est refroidie jusqu'à une température plus basse tandis que la membrane est maintenue dans l'état dilaté et étiré, après quoi la membrane est fixée à la cellule électrolytique ou à un organe de celle-ci.

4. Procédé suivant l'une quelconque des revendications 1 à 3, caractérisé en ce que la membrane est dilatée par étirage uniaxial de la membrane.

5. Procédé suivant l'une quelconque des revendications 1 à 3, caractérisé en ce que la membrane est dilatée par étirage biaxial de la membrane.

6. Procédé suivant l'une quelconque des revendications 1 à 5, caractérisé en ce que la membrane est dilatée par étirage pour augmenter la surface par unité de poids de la membrane d'au moins 50%.

7. Procédé suivant la revendication 6, caractérisé en ce que la membrane est dilatée par étirage pour augmenter la surface par unité de poids de la membrane d'au moins 100%.

8. Procédé suivant l'une quelconque des revendications 1 à 7, caractérisé en ce que la membrane est dilatée par étirage à une température d'au moins 55°C.

9. Procédé suivant la revendication 8, caractérisé en ce que la membrane est recuite par chauffage de la membrane dilatée et étirée à une température d'au moins 55°C.

10. Procédé suivant l'une quelconque des revendications 1 à 9, caractérisé en ce que la membrane est dilatée par étirage à une température élevée et la membrane est refroidie jusqu'à une température plus basse tandis que la membrane est maintenue dans l'état dilaté et étiré, et les stades de dilatation par étirage et de refroidissement sont répétés chacun au moins une fois.

11. Procédé suivant l'une quelconque des revendications 1 à 10, caractérisé en ce que la membrane comprend un fluoropolymère.

12. Procédé suivant l'une quelconque des revendications 1 à 11, caractérisé en ce que les radicaux échangeurs d'ions sont des radicaux acide sulfonique et/ou acide carboxylique, ou des

radicaux convertibles en ceux-ci.

13. Procédé suivant la revendication 12, caractérisé en ce que les radicaux échangeurs d'ions sont des radicaux ester d'acide carboxylique.

14. Procédé suivant l'une quelconque des revendications 1 à 13, caractérisé en ce que la

membrane formée au préalable a une épaisseur de l'intervalle de 0,2 à 2 mm.

15. Procédé suivant l'une quelconque des revendications 1 à 14, caractérisé en ce que la membrane dilatée et étirée à une épaisseur d'au moins 0,02 mm.

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