



166166

Process for treating aqueous solutions comprising bases and organic acids

- 5 The present invention relates to a process for treating aqueous solutions comprising bases and organic acids.

In particular, the invention relates to a process for cleaning up the process water in aldolization reactions

- 10 In many base-catalyzed condensation reactions of organic compounds, in particular in the reaction of aldehydes, carboxylic acids are formed as byproducts, which neutralize some of the catalyst. One process of great industrial importance, is, for example, the condensation of n-butyraldehyde to form 2-ethylhex-2-enal and water. In this case, the reaction mixture is customarily worked up as follows: in the first step, the product-containing
- 15 organic phase is separated from the aqueous phase (catalyst solution and reaction water) in a settling tank. On account of the polarity of the organic acids formed in the side reactions and of the base used as catalyst, these two components are principally in the aqueous phase. Direct feed of this aqueous phase to the effluent treatment plant is therefore frequently
- 20 undesirable, owing to the high loading with bases and organic constituents. In addition, owing to injection of the base from the process together with the aqueous phase, to maintain a constant catalyst concentration, fresh base must constantly be fed to the process, which is cost-intensive and contradicts the actual meaning of catalyst.

- 25 WO 92/07648 discloses a process for recovering sodium hydroxide solution from process waters of the abovementioned type. In this process, the object of which is treating the aqueous phase arising in the aldol condensation, cation-exchange membranes are used. The aqueous phase in this process comprises the sodium salts of the organic acid or alcohol formed as



G00002

byproducts in the aldolization. This solution is passed through the anode chamber in a two-chamber membrane electrolysis cell. When an electric field is applied, the metal cations migrate into the cathode chamber and react with the hydroxide ions formed at the cathode to form sodium hydroxide. In this process, only the sodium hydroxide solution is separated off as catalyst. In the anode circuit, an aqueous solution remains which predominantly comprises only the organic acid or alcohol. Disposal of this solution is complex, since the organic constituents are only present in low concentrations and the solution thus cannot be fed directly to the thermal disposal system. Recovery of the organic acids present in low concentrations is also not worthwhile.

DE 196 04 903 discloses a process for separating off alkali metal hydroxide solution from the product arising in the aldol condensation, which process operates according to the principle of the three-chamber electrolysis or electrodialysis. In this process, the product-containing phase, after separating off the aqueous phase, is passed through the central chamber of the electrolysis cell which is bounded by an anion-exchange membrane and a cation-exchange membrane. In the electric field, in the case of sodium hydroxide solution, the Na^+ ions migrate through the cation-exchange membrane and form, with the OH^- ions produced at the cathode, sodium hydroxide solution in the cathode chamber. The OH^- ions present in the central chamber migrate through the anion-exchange membrane into the anode chamber and react with the H^+ ions produced at the anode to form water. In this process to separate off sodium hydroxide solution, the base is removed from the product, but the base present in the aqueous phase and the organic constituents are not worked up.

In the two abovementioned processes, the phase to be treated is depleted in the course of the electrolysis or electrodialysis in dissolved metal hydroxide, and the conductivity of the solution decreases with advancing electrolysis or electrodialysis. This means that a constantly increasing power input becomes necessary to separate constituents still present in the aqueous solution.

A further known possibility for treating aqueous solutions comprising organic constituents is acidifying the solution until phase separation occurs. However, in this case, only the high-boilers are removed from the solution. the organic acids remain in the aqueous phase. In addition, further salting of
5 the mass stream of the aqueous solution is performed, which makes disposal more difficult.

The object underlying the invention therefore is to provide a simple process for treating aqueous solutions comprising bases and organic acids, which process separates off the bases and organic acids from the solution and
10 provides them together with the treated aqueous solution in a form suitable for further processing or further use.

It has surprisingly now been found that the treatment of aqueous solutions comprising bases and organic acids is considerably simplified by simultaneously separating off bases and organic acids by electrochemical
15 processes.

The present invention therefore relates to a process for treating aqueous solutions comprising bases and organic acids, which comprises simultaneously separating off bases and organic acids by an electrochemical process.

20 Using the process according to the invention, independently of their origin, all aqueous solutions of bases and organic acids can be treated, but in particular those which are produced in aldolization reactions.

In the case of these base-catalyzed aldol condensations carried out in a known manner, such as preparing α,β -unsaturated carbonyl compounds, on
25 account of the reaction mechanism, 1 mol of water is produced per 2 mol of aldehyde or ketone used. In addition, the base is added as aqueous solution to the reaction. After the reaction, an organic phase and an aqueous phase are present. To separate off the desired product, generally, use is made of phase separation by means of a phase separator. The organic phase

principally comprises the desired product, while the aqueous phase comprises the catalyst used and organic constituents, which are frequently produced in side reactions of the aldol condensation. Those to be mentioned here are, in particular, the disproportionation reaction of aldehydes or ketones, which is also known as the Cannizzarro reaction. In this reaction, two molecules of aldehyde or ketone produce one molecule of carboxylic acid and one molecule of alcohol, whose carbon chain length is dependent on the aldehyde or ketone used. The organic acids are readily water soluble up to a chain length of 5 carbon atoms, so that they principally remain in the aqueous phase during the phase separation. This aqueous solution of the basic catalyst and organic acids must usually be post-treated prior to being passed on or discharged. According to the invention, this treatment is performed by an electrochemical process for separating the bases and the organic acids from the aqueous solution.

The bases and organic acids are separated from aqueous solutions by two ways of carrying out the electrochemical process according to the invention: electrolysis and electrodialysis.

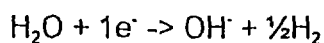
In the electrolytic way of carrying out the invention, the separation is achieved by introducing the aqueous solution to be treated into a chamber disposed between the anode and cathode chambers, the chamber being separated from the anode chamber by at least one anion-exchange membrane and from the cathode chamber by at least one cation-exchange membrane. Commercial membranes can be used. As anion-exchange membrane, use can be made, for example, of the AHA-2 membrane from Tokuyama Soda Ltd. and, as cation-exchange membrane, use can be made, for example, of the C66 10 F membrane from Tokuyama Soda Ltd.

The cathode chamber is preferably incorporated into a reservoir circuit in which the base, preferably the base already present in the solution to be treated, is charged. Flow passes through the cathode chamber counter-currently or cocurrently, preferably cocurrently, to the stream of solution through the central chamber. The anode chamber, in which organic acid.

preferably the acid already present in the aqueous solution to be treated, is charged, is preferably likewise incorporated into a reservoir circuit. Flow likewise passes through the anode chamber countercurrently or cocurrently, preferably cocurrently, to the stream of solution through the central chamber.

- 5 In the anode chamber and cathode chamber is situated in each case at least one electrode, that is to say an anode in the anode chamber and a cathode in the cathode chamber. The cathode consists of a material known to be used for electrolyses, preferably steel. The anode consists according to the invention preferably of steel, platinum black, platinum, graphite, mixed oxide,
 10 or it consists of a combination of these constituents, pure or applied to or incorporated in a support material, preferably titanium.

Applying an electrical voltage forms an electric field between the electrodes. According to the invention, under the influence of the field, the cations, in the case, for example, of the base-catalyzed octenal preparation from butanal
 15 using sodium hydroxide solution as base, the sodium ions migrate through the cation-exchange membrane in the direction toward the cathode and the anions, preferably organic acid radicals, migrate through the anion-exchange membrane in the direction toward the anode. At the cathode in the cathode chamber, the sodium ions together with the hydroxide ions formed at the
 20 electrode in accordance with the formula



form sodium hydroxide solution. At the anode, the negatively charged acid radicals which have migrated into the anode chamber together with the H^+ ions formed at the electrode in accordance with the formula



react to form acid. As a result of the abovementioned processes, the bases and organic acids are separated off from the solution to be treated which is in the central chamber and comprises bases and organic acids, and these

- 6 -

bases and organic acids accumulate in the cathode chamber or the anode chamber (or if appropriate in the corresponding circuits). The process is therefore outstandingly suitable for the simultaneous treatment of aqueous solutions comprising bases and organic acids. Depending on the treatment period, an aqueous solution which is virtually completely freed from bases and organic acids is obtainable, which, without further treatment, can be further used in the process or fed to an effluent treatment plant.

With advancing electrolysis, the aqueous solution in the central chamber is depleted in dissolved ions. The ionic concentration in the cathode chamber, in contrast, increases with advancing electrolysis, since the base formed in the case of NaOH immediately dissociates. In the anode chamber, the ionic concentration changes only insignificantly in the course of electrolysis, since the acid radicals which have migrated through the anion-exchange membrane recombine with the hydrogen ions formed at the anode. The ionic concentration is therefore essentially dependent on the dissociation constant of the acid present in the acid chamber

For the abovementioned reasons, the conductivity at the start of electrolysis is high in the aqueous solution, whereas, in the anode and cathode chambers, it is low or determined by the concentration of base and organic acids of the solutions charged in the reservoirs. With advancing electrolysis, the conductivity in the cathode chamber increases and, at constant current strength, approaches the maximum possible value calculated from the solubility product of the base. The conductivity in the anode chamber remains virtually constant in the course of electrolysis and is low compared with the conductivity in the cathode chamber. According to the invention, therefore, in a preferred embodiment of the process according to the invention, to increase the conductivity of the solution in the anode chamber an acid, preferably a strong mineral acid, such as sulfuric acid, or a base, preferably the base already present in the solution to be treated, is added. This ensures that the ionic concentration and thus the conductivity in the anode circuit remains virtually constant over the entire treatment period and as a result a higher energy input is not necessary. The concentration of the

- 7 -

base in the anode solution, preferably the same base which is present in the aqueous solution to be treated, is according to the invention preferably between 0.01 mol/l and 1 mol/l, in particular, however, between 0.1 mol/l and 0.5 mol/l. The conductivity of the aqueous solution to be treated is used as
 5 a measure of the progression of the process.

By setting a current density greater than from 100 to 200 A/m², two additional treatment effects can be achieved. Firstly, the Kolbe reaction at the anode can be exploited to split the organic acids into water-insoluble hydrocarbons electrochemically in accordance with the formulae



(R is any organic radical) by eliminating CO₂. Since the resulting hydrocarbons are primarily water-insoluble, these can be separated off from the aqueous phase, for example in a phase separator disposed in the anode circuit, and fed to disposal or further processing. By selection of the voltage
 15 supplied, there is also the possibility in this process, depending on which organic acids are formed in the aldolization process, of deciding whether chiefly, the acid or a part of the acid, as hydrocarbon which can be synthesized in accordance with the above-described formulae, is to be produced.

20 The second effect which the process according to the invention can exploit depending on the manner in which it is carried out, is apparently based on an induced convection flow in the membranes. Surprisingly, during the electrolysis even neutral organic compounds are separated off from the aqueous solution to be treated. These compounds frequently occur as
 25 byproducts in aldolization reactions in the aqueous phase in addition to the bases and organic acids. On account of the effect, the neutral organic compounds migrate together with the ions, when an electric field is applied, through the anion-exchange membrane or the cation-exchange membrane from the central chamber which comprises the aqueous solution to be treated
 30 into the anode chamber or cathode chamber, where they can likewise be

- 8 -

separated off by phase separation. The neutral organic compounds thus obtained can again be fed to a separate disposal or further processing

The second way of carrying out the process according to the invention is electro dialysis, which is preferably used if relatively large volumes of solutions are to be treated or treatment of the solution comprising bases and organic acids is to be performed in a relatively short time. For this purpose the number of chambers in the electrolysis module is increased in such a manner that, between the outer chambers which receive the electrodes which correspond to those in the electrolytic way of carrying out the process according to the invention, instead of one chamber which comprises the solution to be treated, the number X of chambers is introduced, where X obeys the formula $X = 1 + 3 \cdot n$, where n is a variable which can be any natural number and 0. These chambers are disposed in such a manner that at least one chamber which comprises the solution to be treated is next to the electrode chambers. For $n = 0$, x has the value 1, which is equivalent to the electrolytic way of carrying out the process according to the invention. For $n = 1$, X takes the value 4, which means that the anode chamber is followed firstly by a chamber comprising the aqueous solution to be treated, then a chamber holding a base, then a chamber holding an acid and finally again a chamber containing the aqueous solution to be treated. The cathode chamber forms the end of this module. For n greater than 1, the electro dialysis module is correspondingly extended by n units consisting of a base chamber, an acid chamber and a chamber comprising the solution to be treated. Figure 2 shows an electro dialysis module in which n takes the value 3.

Just as in the case of the electrolytic way of carrying out the process according to the invention, in the case of the electro dialytic way of carrying out the process according to the invention, also, the cathode chamber and the base chambers which are to receive the base are for preference incorporated jointly or separately, preferably jointly, into a reservoir circuit in which base, preferably the base which is already present in the solution to be treated, is charged. The flow passes through the cathode chamber

- 9 -

countercurrently or cocurrently, preferably cocurrently, to the stream in the chambers bearing the solution to be treated. The flow likewise passes through the base chambers countercurrently or cocurrently, preferably cocurrently, to the flow in the chambers bearing the solution to be treated.

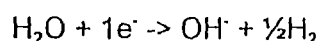
- 5 The anode chamber and the chambers receiving the acid are for preference incorporated jointly or separately, preferably jointly, into a reservoir circuit in which acid, preferably the acid which is already present in the aqueous solution to be treated, is charged. The flow passes through the anode chamber countercurrently or cocurrently, preferably cocurrently, to the flow
10 in the chambers bearing the solution to be treated. The flow likewise passes through the acid chambers countercurrently or cocurrently, preferably cocurrently, to the flow in the chambers bearing the solution to be treated

- Whereas the anode chambers are separated from the chamber comprising the solution to be treated preferably by an anion-exchange membrane and
15 the cathode chambers are separated from the chamber comprising the solution to be treated preferably by a cation-exchange membrane, bipolar membranes are used according to the invention to separate directly adjacently disposed base- or acid-receiving chambers. In the electric field, these membranes produce H^+ and hydroxide ions and release these into the
20 adjacent acid- or base-circuit chambers. The base chambers are separated by cation-exchange membranes from the chambers bearing the aqueous solution to be treated, and the acid chambers are separated by anion-exchange membranes from the chambers bearing the aqueous solution to be treated. Commercial membranes can be used. As anion-exchange
25 membrane, use can be made, for example, of the AHA-2 membrane from Tokuyama Soda Ltd., as cation-exchange membrane, use can be made, for example, of the C66 10F membrane from Tokuyama Soda Ltd. and as bipolar membrane, use can be made of membranes from Aqualytics or Tokuyama Soda Ltd.

- 30 Applying an electric voltage produces an electric field between the electrodes. According to the invention, under the influence of the field, the cations, in the case, for example, of the base-catalyzed octenal preparation

- 10 -

with butanal using sodium hydroxide solution as base, the sodium ions, migrate through the cation-exchange membrane in the direction toward the cathode to the cathode or to a bipolar membrane and the anions, preferably organic acid radicals, migrate through the anion-exchange membrane in the direction toward the anode to the anode or to a bipolar membrane. At the cathode in the cathode chamber and at the bipolar membranes on the base-circuit side, the sodium ions together with the hydroxide ions formed at the cathode in accordance with the formula



or at the bipolar membranes by cleavage of water into OH^- and H^+ ions, form sodium hydroxide solution. At the anode or at the bipolar membranes, the negatively charged acid radicals which have migrated into the anode chamber or the acid chamber react with the H^+ ions formed at the anode in accordance with the formula



or at the bipolar membranes by cleavage of water into OH^- and H^+ ions to form the acid. By means of the abovementioned processes, the bases and organic acids are separated off from the solution to be treated which comprises bases and organic acids and the bases accumulate in the cathode chamber and in the base chambers, and the organic acids accumulate in the anode chamber and in the acid chambers. The process is therefore outstandingly suitable for the simultaneous treatment of relatively large volumes of aqueous solutions comprising bases and organic acids. Depending on the treatment duration and intensity, an aqueous solution is formed which is virtually completely free from bases and organic acids and which, without further treatment, can be further processed or fed to an effluent treatment plant.

With continuing electrodialysis, the aqueous solution in the chambers bearing the solution to be treated is depleted in dissolved ions. The ionic

- 11 -

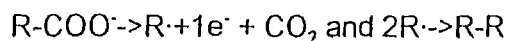
concentration in the cathode chamber and in the base chambers, in contrast generally increases with continuing electrodialysis, since the base formed usually dissociates immediately. In the anode chamber and in the acid chambers, the ionic concentration changes only insignificantly in the course of the electrodialysis, since the acid radicals which have migrated through the anion-exchange membrane recombine with the hydrogen ions formed at the anode or at the bipolar membranes. The ionic concentration is therefore essentially dependent on the dissociation constant of the acid present in the acid chambers

10 For the abovementioned reasons, the conductivity at the start of the electrolysis is high in the aqueous solution, whereas, in the anode and cathode chambers, or in the acid and base chambers, it is low or determined by the concentration of bases and organic acids in the solutions charged into the reservoirs. As the electrolysis continues, the conductivity increases in the cathode chamber and in the base chambers and at constant current strength approaches the maximum possible value. The conductivity in the anode chamber and in the acid chambers remains generally virtually constant in the course of the electrolysis and is low compared with the conductivity in the cathode chamber and in the base chambers. According to the invention, therefore, in a preferred embodiment of the process according to the invention, a base is added, as in the case of the electrolysis, to increase the conductivity of the solution in the anode chamber and in the acid chambers. Adding bases to the anode chamber and to the acid chambers therefore ensures that the ionic concentration and thus the conductivity remains virtually constant in the anode circuit over the entire period of treatment and, as a result, a higher energy input is not required. The concentration of the bases in the anode solution or in the acid circuit, preferably of the same base which is present in the aqueous solution to be treated, is, according to the invention, preferably between 0.01 mol/l and 1 mol/l, but in particular between 0.1 mol/l and 0.5 mol/l. The conductivity of the aqueous solution to be treated is used as a measure of the progression of the process.

By setting a current density according to the invention above 100 to 1000

- 12 -

A/m², two additional treatment effects can be achieved. Firstly, the Kolbe reaction at the anode can be exploited to split the organic acids electrochemically into water-insoluble hydrocarbons according to the formulae



- 5 (R is any organic radical) by eliminating CO₂. Since the resulting hydrocarbons are chiefly water-insoluble, these can be separated off from the aqueous phase, for example in a phase separator disposed in the anode circuit, and fed to disposal or further processing. By selecting the voltage applied, there is therefore the possibility with this process of deciding
 10 depending on which organic acids are formed in the aldolization process, whether the acid or a part of the acid as hydrocarbon which can be synthesized in accordance with the formula given above is to be produced. Since the Kolbe reaction only takes place directly at the anode, in the case of the electrodialytic way of carrying out the process according to the invention,
 15 tion, only a small part of the acid can be converted into a hydrocarbon.

- The second effect which the process according to the invention, depending on how it is carried out, can exploit, is apparently based on an induced convection flow in the membranes. Surprisingly, during the electrolysis, even neutral organic compounds are separated off from the aqueous solution to be
 20 treated. These compounds frequently occur in the aqueous phase in addition to the bases and organic acids as byproducts in aldolization reactions. As a result of the abovementioned effect, the neutral organic compounds together with the ions migrate through the anion-exchange membrane or the cation-exchange membrane from the chamber which comprises the aqueous
 25 solution to be treated into the anode and cathode chambers or the base and acid chambers where they can likewise be separated off by phase separation. The neutral organic compounds thus obtained can again be fed to disposal or further processing.

- Preferably, the bases, after separating them off from the aqueous solution to
 30 be treated, are taken up outside the cell by pure bases charged there and in

- 13 -

this manner concentrated and recovered. The bases worked up in this manner are preferably fed back to the aldolization process as catalyst. The organic constituents in the acid circuit separated off from the aqueous solution to be treated are concentrated and either fed directly to thermal disposal or further processed, e.g. separated by means of a phase separator into water-soluble and water-insoluble compounds and disposed of or further processed individually. The aqueous solution treated according to the invention can be fed to an effluent treatment plant, to a combustion unit or to further processing

- 10 The process according to the invention is for preference carried out at atmospheric pressure and preferably at temperatures between 20°C and 90°C, particularly preferably at 30°C to 60°C.

The process according to the invention can be carried out continuously or batchwise by the electrolytic or electrodialytic method. The strength of the electric field applied is dependent, inter alia, on equipment conditions and material pairs, and must be dimensioned in such a manner that the effect according to the invention is achieved. Preferably, a current density of from 100 to 1000 A/m² is used.

20 In Figures 1 and 2, two ways of carrying out the process according to the invention are shown as examples, without the process being restricted thereto.

Figure 1 shows an electrolytic way of carrying out the process according to the invention. The electrolysis module is divided into three chambers 1, 2 and 3 by an anion-exchange membrane A and a cation-exchange membrane K. The aqueous solution to be treated, in this example a waste water stream which comprises NaOH and the sodium salt of butyric acid, NaBs, flows through the central chamber 2. The anode chamber 1, in which is disposed the anode indicated by +, is incorporated into a reservoir circuit and a solution comprising the organic acid HBs, which is charged from the reservoir V1, flows through it. The cathode chamber 3 in which the cathode indicated

- 14 -

by - is disposed is incorporated into a reservoir circuit and an NaOH-containing solution which is charged from the reservoir V3 flows through it. In the electric field, the Na^+ ions migrate through the cation-exchange membrane K into the cathode chamber 3, where, with the OH^- ions formed at the cathode (-), they form sodium hydroxide solution. The H^+ ions formed at the anode (+) react with the anions OH^- and Bs^- which have migrated through the anion-exchange membrane A, to form organic acid and water.

An electrodialytic way of carrying out the process according to the invention is shown in Figure 2. The electrolysis module is divided by four anion-exchange membranes A, four cation-exchange membranes K and three bipolar membranes BM into a cathode chamber 1, an anode chamber 3, four chambers 2 bearing solution to be treated, three base chambers 4 and three acid chambers 5. The aqueous solution to be treated, in this example a waste water stream which comprises NaOH and the sodium salt of butyric acid NaBs, flows through the chambers 2. A solution comprising the organic acid HBs, which is charged from the reservoir V1, flows cocurrently through the anode chamber 1, in which is disposed the anode indicated by (+), and the acid chambers 5. The solutions exiting from the acid chambers 5, through which the flow passes cocurrently to the chambers 2, combine, after flowing through the chambers, with the solution from the anode chamber and are collected again in a reservoir V1. From this reservoir, the solution is passed to the chambers, with the solution being divided over chambers 1 and 5. The cathode chamber 3, in which is disposed the cathode marked by (-), is fed cocurrently by a solution comprising NaOH, which solution is charged from the reservoir V3. The base chambers 4 are likewise fed cocurrently by the solution charged in the reservoir V3. The solutions of the cathode chamber and the base chambers combine, after flowing through the electrodialysis module, and are collected again in the reservoir V3. In the electric field, the Na^+ ions migrate from the chambers 2 through the cation-exchange membrane K into the cathode chamber 3 or into the base chambers 4, where, together with the OH^- ions formed at the cathode (-) and the bipolar membranes BM, they form sodium hydroxide solution. The H^+ ions formed at

- 15 -

the anode (+) or at the bipolar membranes BM react with the anions OH^- and Bs^- which have migrated through the anion-exchange membrane A from the chambers 2 into the chamber 1 or the chambers 5, to form organic acid and water.

- 5 The processes according to the invention are described in more detail by the following examples, without being restricted thereto. In the examples, the process is illustrated with reference to electrolysis, since this is also the basis of the electrodialytic design and other variants.

Example 1:

- 10 Purification of the reaction water from octenal production

Electrolysis was carried out at a temperature of from 40 to 50°C at a current density of 350 A/m² in a three-chamber electrolysis module as in Figure 1, whose chambers are separated by an anion-exchange membrane of type AHA-2 and a cation-exchange membrane of type C66 10F from Tokuyama Soda Ltd., each of which have a membrane area of 100 cm², using an anode of titanium coated with mixed oxide having a surface area of 100 cm² and a cathode of expanded stainless steel metal having a surface area of 100 cm². In the anode circuit, a 1% strength aqueous sodium hydroxide solution was charged, and in the cathode circuit a 5% strength aqueous butyric acid solution was charged. In the central chamber, octenal waste water which comprised, inter alia, butyric acid and various aldehydes, was circulated. The conductivities of the solutions were determined constantly during the entire electrodialysis operation using a measuring instrument from WTW.

In the course of the electrodialysis, the conductivity in the octenal circuit decreased to very low values (0.1 mS/cm). In the anode circuit, the conductivity remained virtually constant, whereas in the cathode circuit the conductivity increased with increasing duration of the electrodialysis up to a maximum value of > 180 mS/cm. Figures 3 to 5 show the time course of the conductivities in the three chambers. Figure 3 shows the course of conductivity in the anode chamber, Figure 4 shows the course of conductivity

- 16 -

in the chamber comprising the solution to be treated and Figure 5 gives the course of conductivity in the cathode chamber.

At the start and finish of the electrolysis, samples were taken from the central chamber and the total carbon content and sodium content of the solution
5 were determined. The measured values may be read off from the table below.

Table: Analytical results of samples taken from the central electrolysis chamber

Analyses of total carbon content				
Sample 1 (start of electrolysis)	0.93	%C	8.77	g carbon
Sample 2 (finish of electrolysis)	0.098	%C	0.81	g carbon
Analyses of sodium content				
Sample 1 (start of electrolysis)	1.4	% Na	13.20	g sodium
Sample 2 (finish of electrolysis)	0.01	%Na	0.08	g sodium

The marked decrease in total carbon content in the central chamber is particularly noticeable. Thus, in the course of the electrolysis, the carbon content decreased from 0.93% to 0.098%. This is all the more important since actually only 0.6% was charged as organic acid, and thus the residual carbon content due to neutral organic compounds was 0.33%. Since the final content was markedly beneath this value, this denotes that even neutral organic compounds migrate from the central chamber through the membranes.

Example 2:

An electrodialysis was carried out using the same experimental parameters in an electrodialysis module as shown in Fig. 2. In addition, in this example sodium hydroxide solution was added to the butyric acid in the anode or acid circuit until the pH was approximately 6.0. Measurement of the conductivity in the anode or acid circuit showed a significantly higher conductivity compared with that determined in Example 1. The measured values of conductivities in the three circuits are shown plotted graphically against the experimental time in Figures 6 to 8.

Figure 6 shows the course of conductivity in the anode chamber or the acid

- 18 -

chambers, Figure 7 shows the course of conductivity in the chambers comprising the solution to be treated and Figure 8 shows the course of conductivity in the cathode chamber or base circuit. The addition of sodium hydroxide solution to the acid circuit therefore causes a substantially higher
5 and virtually constant conductivity in the anode chamber. As a result thereof the required total energy input to treat the aqueous solution is halved.

Claims:

1. A process for treating aqueous solutions comprising bases and organic acids, which
comprising simultaneously separating off basic catalyst and organic acids by means of an
5 electrochemical process wherein said aqueous solutions are produced in aldolization
reactions.
2. The process as claimed in claim 1, wherein said basis catalyst and said organic acids are
separated off simultaneously by electrolysis.
- 10 3. The process as claimed in claim 1, wherein said basic catalyst and said organic acids are
separated off simultaneously by electrodialysis.
4. The process as claimed in claim 2, wherein said solution to be treated is introduced into a
15 chamber 2 disposed between the anode chamber 1 and cathode chamber 3, wherein the
chamber 2 is separated from the anode chamber 1 by at least one anion-exchange
membrane A and wherein the chamber 2 is separated from the cathode chamber 3 by at
least one cation-exchange membrane K.
- 20 5. The process as claimed in claim 3, wherein, in the electrodialysis, chambers 4 and 5
which serve as reservoirs for receiving cations or anions from said solution to be treated
and are situated between the chambers 2, which are fed with the solution to be treated,
are separated by bipolar membranes BM.
- 25 6. The process as claimed in at least one of claims 1 to 5, wherein acid to which base is
added is charged into the chambers which serve to receive the anions.
7. The process as claimed in at least one of claims 1 to 6, wherein neutral organic
compounds are additionally separated off from the solution to be treated.

8. The process as claimed in at least one of claims 1 to 7, wherein use is made of electrodes of steel, platinum black, graphite, mixed oxide, pure platinum or of a combination of these constituents in pure form or applied to or incorporated in a support material.
- 5 9. The process as claimed in at least one of claims 1 to 8, wherein the process is carried out at from 20 to 90 °C.
10. The process is claimed in claim 9, wherein the separation process is carried out at from 30 to 60 °C.
- 10 11. The process as claimed in at least one of the claims 1 to 10, wherein the process is carried out continuously.
12. The process as claimed in at least one of claims 1 to 10, wherein the process is carried out
15 batchwise.
13. The process as claimed in at least one of the preceding claims, wherein organic compounds are split electrochemically at the anode.
- 20 14. The process as claimed in at least one of claims 1 to 10, wherein the number of chambers between chambers containing an electrode is $X = 1 + 3 \cdot n$.
15. The process as claimed in at least one of the claims 1 to 10, wherein said process is performed in an apparatus having an anode and a cathode as electrodes and wherein a
25 current density of 100 – 1000 A/m² is applied across the electrodes of said apparatus.
16. A process comprising:
Simultaneously, electrochemically separating a basic catalyst and organic acids from an aqueous solution, wherein said aqueous solution is produced in aldolization reactions,
30 wherein a base in an amount of 0,01 – 1 mol/l is added to the aqueous solution in the anode chamber.

17. A process comprising:

Simultaneously, electrochemically separating a basic catalyst and organic acids from an aqueous solution, wherein said aqueous solution is produced in aldolization reactions,
5 wherein an acid to which a base is added is charged into the chambers which serve to receive the anions.

18. A process comprising:

Simultaneously, electrochemically separating a basic catalyst and organic acids from an
10 aqueous solution, wherein said aqueous solution is produced in aldolization reactions, wherein a neutral organic compound is separated from said solution.

19. A process comprising:

Simultaneously, electrochemically separating a basic catalyst and organic acids from an
15 aqueous solution, wherein said aqueous solution is produced in aldolization reactions, wherein organic compounds are split electrochemically at the anode.