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Datasheet for the decision of 23 February 2010

Case Number: T 1492/07 - 3.3.05

Application Number: 96918364.9

Publication Number: 0830196

IPC: B01D 53/34

Language of the proceedings: EN

Title of invention:
Enzyme systems for gas processing

Applicant:
Trachtenberg, Michael C.

Opponent:
-

Headword:
Bioreactor/TRACHTENBERG

Relevant legal provisions:
EPC Art. 54, 56

Relevant legal provisions (EPC 1973):
-

Keyword:
"Novelty (yes)"
"Inventive step (yes) - improvement over state of the art (plausible)"

Decisions cited:
-

Catchword:
-

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Case Number: T 1492/07 - 3.3.05

D E C I S I O N
of the Technical Board of Appeal 3.3.05
of 23 February 2010

Appellant: Trachtenberg, Michael C.
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 5 April 2007 refusing European application No. 96918364.9 pursuant to Article 97(1) EPC 1973.**

Composition of the Board:

Chairman: G. Raths
Members: H. Engl
C. Vallet

Summary of Facts and Submissions

I. The appeal lies from the decision of the examining division posted on 5 April 2007 to refuse European patent application EP 96918364.9. It was held that document

D1: US-A-4 602 987 (Bonaventura *et al.*)

already disclosed a process and a bioreactor for extracting a selected gas (CO_2) from a gaseous mixture by direct contact with an immobilised enzyme. A first gas phase zone and a liquid phase were separated by a semi-permeable wall supporting the said immobilized enzyme. The extracted CO_2 was transferred to the liquid phase and converted to an aqueous stream of bicarbonate solution. Therefore, the subject matter of claims 1 and 8 lacked novelty having regard to document D1.

II. The following documents were also part of the procedure:

D2: US-A-3 910 780 (Henley *et al.*)
D3: JP-A-1 312 993 (Teijin Ltd)
&
D3a: WPI/Derwent Abstract AN 90-034178
D4: US-A-5 116 506 (Williamson *et al.*)
D5: DE-A-26 43 414 (I.H. Scheinberg)
D6: DE-C-40 27 126 (E. Bock, E. Biller)

III. The appeal of the applicant (appellant) was filed with letter dated 15 June 2007; the grounds of appeal were submitted with letter dated 15 August 2007.

IV. The board issued a summons to oral proceedings in which it raised objections under Articles 84 and 123(2) EPC against claim 1. Moreover, the bioreactor of claim 1 appeared to lack novelty having regard to D1.

V. Oral proceedings took place on 23 February 2010. The appellant filed amended claims 1 to 7 as its new sole request.

Claim 1 thereof reads:

"A bioreactor which comprises a vessel having a gas inlet and a gas outlet, said vessel having a gas inlet zone in communication with said gas inlet, and a second phase zone (16) in which the gas inlet zone and the second phase zone are separated by a wall (4) a portion (9) of which is permeable to at least one selected gas and which retains a second phase in the second phase zone (16), said permeable portion (9) also comprising a support surface (8) with at least one solvated enzyme (12) fixed on said support surface (8) wherein the enzyme active site is in direct contact with the gas phase in the gas inlet zone so as to allow the selected gas to be converted to a product in a condensed phase by contact with the solvated enzyme, said enzyme removing the selected gas from the gas inlet zone, the product resulting from action of said enzyme passing into the second phase zone."

VI. The appellant's arguments may be summarized as follows:

i *Novelty*

D1 taught a bioreactor in which the immobilized

enzyme was present in the aqueous phase. The enzyme contacted the carbon dioxide in the said aqueous phase. There was no disclosure in D1 of the active site of the enzyme being in contact with the fluid in the fluid inlet zone so as to allow the selected gas to be converted to a product in a condensed phase.

ii *Inventive step*

Starting from D1, the appellant defined the technical problem as the provision of a faster, more economical and efficient bioreactor.

This problem was successfully solved by directing the enzyme catalysed reaction to the phase interface, and away from the aqueous phase. By placing the active site of the enzyme at the gas-liquid interface, the selected gas reacted via the catalyst immediately upon contact, thereby avoiding the problem of competition from physical absorption and non-catalysed reactions. Such an apparatus was not taught in D1.

D3 disclosed a bioreactor element for separating oxygen having an enzyme immobilised on a gas separating membrane. There was no indication of the orientation of the active site of the enzyme, nor any suggestion of a catalysed reaction.

VII. Requests

The appellant requested that the decision under appeal be set aside and a patent be granted on the basis of the set of claims 1 to 7 filed during oral proceedings.

Reasons for the Decision

1. Amendments

The amended claims relate to a bioreactor as defined in claim 12 and disclosed in Figures 1 to 3 of the application as originally filed (WO-A-96/40414).

The feature of claim 1 defining "*at least one solvated enzyme (12) fixed on said support surface (8) wherein the enzyme active site is in direct contact with the gas phase*" is disclosed on page 4, lines 15 to 20, of the originally filed application documents in connection with a process for gas separation. The feature relates to the immobilization of the enzyme on the support surface (8) and to the orientation of the enzyme. The board considers that it is unambiguously and directly derivable from the application as a whole that this feature applies not only to the said process, but also to the bioreactor used for putting the process into practice.

The claim feature "*the product resulting from action of said enzyme passing into the second phase zone*" is disclosed in the originally filed application on page 8, lines 1 to 5.

Further claim features, in particular the features relating to "*a wall (4) a portion (9) of which is permeable to at least one selected gas and which retains a second phase in the second phase zone (16), said permeable portion (9) also comprising a support surface (8)*" are based on page 7, lines 24 to 39 of the application documents as filed (WO-A-96/40414).

The dependent claims 2 to 6 are based on original claims 13 to 17, respectively. Claim 7 is based on the disclosure of carbonic anhydrase as an enzyme in example 2.

The requirements of Article 123(2) EPC are therefore met.

2. Novelty

2.1 D1 discloses a process and apparatus for separating carbon dioxide from a fluid stream by enzyme catalyzed reaction of CO_2 to carbonic acid (see column 25, line 12 to column 26, line 21; column 30, line 1 to col. 31, line 15; Figures 6 and 7). The carbonic acid passes into a second reaction zone comprising a condensed phase (see Figure 6, Figure 7).

The apparatus features a fluid inlet 27, a fluid outlet 28, a gas-permeable membrane 25 and a compartment 23 containing a condensed phase.

Although the major part of D1 concerns gas separation from a liquid phase, it is stated in column 25, lines 19 and 20, that the fluid may also be a gas.

Accordingly, when carbon dioxide is being extracted from a liquid, *"it is preferred to contact the liquid stream with a membrane which divides the liquid stream from an aqueous solution which is in contact with the immobilized enzyme. Such an arrangement is considered to involve "contact" between the enzyme and the fluid from which carbon dioxide is being removed for the purposes of this invention. It is also possible to attach the enzyme directly to or entrap the enzyme in the membrane which separates the fluid and aqueous phases. Inclusion of carbonic anhydrase in or on the membrane allows more rapid passage of carbon dioxide across the membrane*." (emphasis added by the board) (column 25, lines 21 to 32).

D1 does not explicitly disclose solvated enzymes. However, the board considers that an enzyme, to be in a catalytically active state, needs solvation. Therefore, this condition is considered to be implicitly fulfilled in D1.

Furthermore, D1 also does not disclose that the active sites of the enzymes are in direct contact with the gas phase. The passage in column 25, lines 24 to 27, quoted above clearly refers to a situation where carbon dioxide is extracted from a liquid (in which carbon dioxide is dissolved), not from a gas (*cf.* the immediately preceding sentence). Therefore, there can be no "contact", let alone a direct one, between a gas phase and the enzyme or its active site, as far as this embodiment is concerned.

D1 also discloses an embodiment in which CO_2 is extracted from a gas and the enzyme is trapped in or

covalently attached to a porous substrate (column 25, lines 27 to 30). The enzyme (carbonic anhydrase) may also be *"immobilized on a surface or entrapped within the gas permeable membrane itself"* (column 26, lines 1 to 3). However, there is no disclosure of the enzyme active sites being in direct contact with the said gas. Rather, it appears from Figure 6 and the corresponding description, column 30, lines 15 to 53, that the selected gas (carbon dioxide) has to pass through the gas permeable membrane 25 into compartment 23 before coming into contact and reacting with the immobilized enzyme 24. Incidentally it is noted that reference sign "22" in the sentence in column 30, lines 42 to 44, is incorrect and should read "23", as is clear in the context. For these reasons, the board cannot share the examining division's view as expressed in the contested decision that D1 discloses the selected gas (CO_2) as being in direct contact with the (active site of the) enzyme.

2.2 D2 discloses an underwater breathing apparatus for the separation of CO_2 from a mixture of CO_2 and other gases using a membranous element impregnated with a catalyst for hydration of CO_2 to carbonic acid. The membrane may consist of a porous hydrophobic polymer (PTFE) onto which the catalyst is impregnated. However, the catalyst is not an enzyme, but an inorganic salt.

2.3 D3 also describes a bioreactor for gas separation which uses a hollow polysulfone fibre membrane impregnated with an immobilized bio-catalyst (acetobacter). According to D3a, there is no disclosure of any particular orientation of the enzyme.

2.4 The board is also satisfied that none of the remaining documents cited in the International Search Report and in the Supplementary European Search Report discloses all of the claim's features in combination.

2.5. The claimed subject matter is therefore novel (Article 54(1) (2) EPC).

3. Inventive step

3.1 The claimed invention is concerned with a bioreactor for gas separation wherein a selected gas in a mixed gas stream is contacted by an enzyme having an active site in direct contact with the said gas, said enzyme removing the selected gas from the gas stream.

3.2 D1 discloses a process and apparatus for separating carbon dioxide from a fluid stream by enzyme catalysed reaction of CO_2 to carbonic acid (see point 2.1). The board regards document D1 as representing the closest prior art, as did the appellant.

3.3 Starting from D1, the technical problem underlying the application may be defined as the provision of a faster, more economical and more efficient bioreactor.

3.4 As a solution to this technical problem, the application proposes a bioreactor according to claim 1, characterized in that it comprises a support surface (8) with at least one solvated enzyme (12) fixed thereon such that the enzyme active site is in direct contact with the gas phase in the gas inlet zone.

3.5 The appellant argued that the above defined problem was successfully solved by the claimed bioreactor, because it directed the enzyme catalysed reaction to the phase interface, and away from the aqueous phase. By placing the active site of the enzyme at the gas-liquid interface, the selected gas reacted via the catalyst immediately upon contact, thereby avoiding the problem of competition from physical absorption and non-catalysed reactions.

The board accepts these explanations of a more efficient reaction mechanism. In particular, it is plausible to the board that the claimed direct contact of the enzyme with the gas stream avoids the additional process step of dissolution of the selected gas in the second phase before contact with the enzyme, which is necessary in prior art bioreactors, thereby making the overall process faster. The board also accepts the argument that the claimed fixation and orientation of the enzyme such that the active sites are in direct contact with the gas phase in the inlet zone of the claimed bioreactor can be achieved by immobilization techniques such as described on page 9, line 27 to page 11, line 2, of the patent application. In preferred embodiments the enzyme may be modified by altering the DNA segment coding for the enzyme to add a sequence coding for an amino acid sequence that yields a binding moiety to the enzyme in a manner that enhances enzyme binding (see page 10, lines 20 to 23). It is plausible to the board that these immobilization techniques and others, such as the techniques disclosed in connection with example 1 (page 14, lines 5 to 22), and the references cited there, not only enhance enzyme binding, but also serve to orientate the enzymes'

active sites in the desired manner. In view of these advantages, *i.e.* higher efficiency, faster process, it is credible that the process in the claimed bioreactor is more economical.

The board is thus satisfied that the problem posed has been successfully solved.

3.6 It remains to be decided whether the claimed solution is obvious in view of the prior art.

As discussed by the board under point 2.1 above, the crucial feature of the claimed invention, *i.e.* the orientation of the enzyme such that its active site is in direct contact with the gas phase in the gas inlet zone, is not taught in D1. This claim feature is also not suggested by any other available document.

D2 teaches an underwater breathing apparatus comprising a porous hydrophobic membrane impregnated with a hydration catalyst. However, the catalyst is inorganic and there is no suggestion of it being oriented towards the gas phase.

Document D4 discloses a bioreactor wherein a gas permeable membrane divides a reactor vessel into a liquid compartment and a gas compartment. A catalytic biofilm is grown on the gas permeable membrane on the liquid side of the membrane (abstract, Figure 1, column 4, lines 31 to 56). Therefore, D4 cannot suggest the claimed bioreactor either.

Document D5 discloses a method and filtering apparatus for the enzymatic removal and oxidation of carbon

monoxide from a gas stream, in particular from tobacco smoke. The enzyme is present either in suspension in a gas absorption apparatus (Figure 1; page 15, last paragraph) or in the form of a porous filter element (Figure 2). As there is no permeable support surface for the enzyme separating a gas phase from a condensed phase, D4 cannot lead the skilled person in the direction of the claimed invention.

Lastly, document D6 discloses a process and an apparatus for removing a selected gas from a gas stream, wherein the gas stream passes a number of hollow membranous bodies containing a suspension of microorganisms. D6 thus neither suggests the immobilization of an enzyme on a permeable support nor the orientation of the enzyme's active site towards the gas phase.

3.7 It follows from the above that the prior art does not provide the skilled person with an incentive to look for the claimed apparatus, in view of the problem posed.

The subject matter of claim 1 therefore meets the requirement of Article 56 EPC.

Claims 2 to 7 define preferred embodiments of the bioreactor of claim 1, on which they depend. These claims therefore derive their patentability from claim 1.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the department of first instance with the order to grant a patent on the basis of the set of claims 1 to 7 filed in the oral proceedings and the description and the drawings to be adapted.

The Registrar | The Chairman

C. Vodz | G. Raths