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D E C I S I O N
of 11 August 1998

Case Number: T 0259/94 - 3.3.1

Application Number: 87110385.9

Publication Number: 0253409

IPC: C07C 57/055

Language of the proceedings: EN

Title of invention:
Anhydrous diluents for the propylene oxidation reaction to acrolein and acrolein oxidation to acrylic acid

Patentee:
Union Carbide Corporation

Opponent:
BASF Aktiengesellschaft, Ludwigshafen

Headword:
Anhydrous diluents/UNION CARBIDE

Relevant legal provisions:
EPC Art. 54, 56, 114(2), 123

Keyword:
"Novelty (yes) - features not implicitly disclosed - multiple selection"
"Inventive step (yes) - determination of the closest state of the art - proper comparison - unexpected effect"
"Late filed evidence: admitted (no) - lack of relevance; admitted (yes) - no objection from respondent"

Decisions cited:
T 0037/82, T 0689/91, T 0482/92, T 1002/92, T 0039/93, T 0298/92, T 1016/93

Catchword:
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Beschwerdekammern | Boards of Appeal | Chambres de recours

Case Number: T 0259/94 - 3.3.1

D E C I S I O N
of the Technical Board of Appeal 3.3.1
of 11 August 1998

Appellant: (Opponent)
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Decision under appeal: **Interlocutory decision of the Opposition Division of the European Patent Office posted 26 January 1994 concerning maintenance of European patent No. 0 253 409 in amended form.**

Composition of the Board:

Chairman: A. J. Nuss
Members: R. Freimuth
W. Moser

Summary of Facts and Submissions

I. The Appellant (Opponent) lodged an appeal on 19 March 1994 against the interlocutory decision of the Opposition Division, posted on 26 January 1994, which found that the European patent No. 253 409 in the form as amended during opposition proceedings met the requirements of the EPC.

II. The opposition was based on the grounds of lack of novelty and inventive step and was supported by several documents including:

(1) DE-A-2 436 818
(2) DE-A-2 729 841
(3) DE-A-1 962 431
(4) DE-A-1 468 429
(5) DE-A-2 056 614 and
(6) DE-A-3 006 894.

III. The decision was based on claims 1 to 9; claim 1 was filed on 17 December 1993, claim 2 was filed during oral proceedings before the Opposition Division, and claims 3 to 9 were as granted. The amended claims 1 and 2 read as follows:

"1. Process for producing acrylic acid by a two-stage catalytic oxidation of propylene, wherein the first stage produces primarily acrolein and the second stage produces primarily acrylic acid by oxidation of acrolein, said process utilizing one or more recycle streams to either or both stages, both stages operating on feed streams containing oxygen and an inert diluent gas,

characterized in that as the diluent gas to the first stage a gas mixture is utilized which comprises 0 to 0.4 mole of steam per mole of propylene, the remainder of the diluent gas comprising one or more inert gases such that the diluent gas has a composite heat capacity of at least 8 calories/gram-mole (°C) and that as the diluent gas to the second stage a gas comprising one or more inert gases having a composite heat capacity of at least 6.5 calories/gram-mole (°C) is employed.

2. A process of claim 1 wherein the composite heat capacity of the inert diluent gas to the first stage is 8 to 40 calories/gram-mole (°C)."

IV. The Opposition Division held that the subject-matter of claim 1 as amended was novel due to the rise in the minimum value of the composite heat capacity to 8 calories/gram-mole (°C) of the diluent gas used in the first stage. The documents (1) and (2) disclosed a maximum value of 7.20 calories/gram-mole (°C) according to the calculations of the Appellant.

Concerning inventive step the Opposition Division held that the patent in suit contained two essential features, i.e. the use of not more than 0.4 mole steam per mole of propene and the use of a diluent gas having a minimum heat capacity of 8 calories/gram-mole (°C) in the first stage. The first feature was disclosed already in document (1), and document (3) explicitly taught that the presence of steam enhanced the production of the by-product acetic acid. The second feature was not to be found in the available prior art and resulted in improved yields of acrolein and acrylic acid as shown in example 11 compared to examples 12, 13 and 14 of the patent specification. Document (3) indicated to replace steam by a different diluent gas, preferably nitrogen which had a heat capacity of only

7.11 calories/gram-mole (°C), in order to reduce the by-product acetic acid. The patent in suit linked the yield of wanted products directly to the nature of the diluent gas, specifying a minimum heat capacity of 8 calories/gram-mole (°C). Nitrogen did not satisfy this feature. Although diluent gases having the required heat capacity were disclosed in document (3), none of the 18 examples had been carried out with them. Document (5) dealt with the problem of "overoxidation" when steam was replaced by gases having a lower heat capacity. It proposed a solution different to that in the patent in suit, namely to dilute the catalyst with an inert material. The use of diluent gases having a high heat capacity reduced the overoxidation, demonstrated by a decrease of the production of carbon dioxide, which, however, was not linked to an increase of the yield in acrolein and acrylic acid. The Opposition Division concluded that the unexpected effect of improving the yield of acrolein and acrylic acid rendered the claimed process inventive.

V. Oral proceedings were held on 11 August 1998.

VI. The Appellant argued that the claimed subject-matter was neither novel nor inventive, essentially for the following reasons:

A. Document (3) referred to a process for producing acrylic acid by oxidation of propene. The two-stage character of this oxidation process was inherently disclosed in document (3), since the oxidation proceeded via the intermediate acrolein. Carbon dioxide and saturated hydrocarbons, both having heat capacities of at least 8 calories/gram-mole (°C) as required by claim 1 of the patent in suit as amended, were disclosed as inert diluent gases. The feature in claim 1 of the

patent in suit of utilizing recycle streams was implicitly disclosed to the skilled reader due to economical reasons. Therefore this document destroyed the novelty of the claimed subject-matter.

B. Document (6) disclosed, as the first stage, the oxidation of propene to acrolein in the presence of carbon dioxide as inert diluent gas and, as the second stage, the oxidation of this reaction product to acrylic acid. The feature in claim 1 of the patent in suit of utilizing recycle streams was implicitly disclosed to the skilled person. Therefore this document anticipated the subject-matter claimed.

C. The fresh document filed on 26 January 1995

(10) GB-A-1 450 986

was to be allowed into the proceedings for its relevance (see decision T 1016/93, not published in OJ EPO). It destroyed the novelty of the patent in suit. This document disclosed in general the catalytical oxidation of hydrocarbons to carboxylic acids in the presence of carbon dioxide as inert diluent gas which had a heat capacity of 11.1 cal/mol K. The carbon dioxide was recycled. This general process was to be applied to the oxidation of propene to acrylic acid, which had inherently two stages.

D. Document (3) recommended carrying out the first oxidation stage in the absence of steam. The document (5) taught that the substitution of diluent gases having a lower heat capacity for steam resulted in overoxidation. This was supposed to be tantamount to a reduction of the selectivity

in the formation of acrolein/acrylic acid, since overoxidation meant to burn a part of the wanted products to carbon dioxide and carbon monoxide. The skilled person wanting to substitute another diluent gas for steam had no other choice in view of document (5) than to use a diluent gas having a heat capacity above 8 cal/K, since steam had already a value of 8.62 cal/K. The claimed subject-matter resulted from the obvious combination of document (3) with document (5). Furthermore, document (3) did not contain any prejudice with general validity which would have prevented the skilled person from following the teaching of the art. Document (4) taught on page 5, paragraph 2, the optional incorporation of the diluent gases carbon dioxide, nitrogen, saturated hydrocarbons or steam. They showed a heat capacity above 8 calories/gram-mole (°C), except nitrogen. This teaching therefore gave an additional hint to the claimed invention.

The two features included in claim 1 of the patent in suit, i.e. "two-stage process" and "utilizing one or more recycle streams to either or both stages", did not contribute to the technical result; the only such contribution came from the specific diluent gas. According to the "problem-solution approach" to be adopted, those features not contributing to the technical result should be excluded from the assessment of inventive step (see decision T 37/82, OJ EPO 1988, 86).

E. The only comparable examples of the patent in suit, i.e. the examples 10 and 12, admittedly showed that the increase of the molar heat capacity of the diluent gas resulted in a decrease of the formation of carbon dioxide/monoxide and in an increase of the overall yield of acrolein and

acrylic acid. To be convincing, a comparison of yields required identical conversion rates. If this requirement was not satisfied, the yield should be standardized on the basis of a constant conversion rate; this was called the selectivity. A fair comparison of selectivities required identical conversion rates as set out in the new document

(11) "ABC Verfahrenstechnik", VEB Deutscher Verlag für Grundstoffindustrie, Leipzig 1979, page 383, column 2,

filed on 5 March 1996. The calculated selectivity between the examples and the comparative examples of the patent in suit - except for example 12 - could hardly be distinguished and was within the scope of measuring inaccuracy. Based on the Appellant's test reports, filed on 6 July 1995 and 5 March 1996, which were carried out in analogy to examples 4, 10, 12 and 13 of the patent in suit, the increase of the heat capacity of the diluent gas resulted in an increase of the selectivity and a decrease of the formation of carbon dioxide. This result was in line with the examples of the patent in suit, but expected by the skilled person.

F. The examples of the patent in suit did not specify the catalysts used therein, with the consequence that the Appellant was unable to verify their results. During oral proceedings he confirmed that this objection did not amount to an insufficient disclosure within the meaning of Article 100(b) EPC.

G. Document (10) taught the advantages of the use of carbon dioxide as diluent gas, namely the increase in educt concentration without the danger of explosion, avoidance of temperature peaks due to its improved withdrawal of heat, and increase in product selectivity. These advantages were, however, just those which the Respondent relied on to support inventive step. Consequently this document, if not destroying novelty, took away inventive step.

The carbon dioxide was inert in the oxidation process. This could be deduced from the examples on page 3, lines 54 to 57, disclosing that the concentration of carbon dioxide remained constant in the circulating gas during the oxidation process.

VII. The Respondent (Proprietor of the Patent) argued that none of the cited documents anticipated the subject-matter of the patent in suit and that none of the cited documents, alone or in combination, rendered the subject-matter of the patent in suit obvious, essentially for the following reasons:

A. Document (3) did not disclose the features:

(a) two-stage process,

(b) composite heat capacity of the diluent gas to the first stage of at least 8 calories/gram-mole (°C) and

(c) utilization of a recycle stream,

with the consequence that it did not anticipate the subject-matter of the patent in suit. With regard to feature (a), the **process** was defined to

be carried out in two stages, whereas the Appellant's argument referred to a **reaction mechanism** involving two stages. The prior art made a clear distinction between two-stage and one-stage processes for preparing acrylic acid from propene, reference being made particularly to documents (3), (4) and (1). With regard to feature (b), carbon dioxide and saturated hydrocarbons had only been superficially mentioned as diluent gases in document (3) and had not been used in any of its examples. On the contrary, the diluent gas particularly recommended in this document was nitrogen having a capacity only slightly above 7 calories/gram-mole (°C). With regard to feature (c), this was nowhere disclosed in document (3), not even implicitly. The latter document explicitly stated on page 2, last paragraph, that the recycling step was not necessary.

B. Document (6) did not disclose a two-stage process in combination with the exclusive use of carbon dioxide as diluent gas in the first step. The use of carbon dioxide referred to a one-stage process, and the exclusive use of carbon dioxide was not mentioned at all. In any case, the use of recycling streams was not disclosed in this document. Therefore, it could not anticipate the claimed process.

C. Document (10) was to be objected to for its very late filing; it should not be admitted into the proceedings for its lack of "prima facie high relevance" in view of the decision T 1002/92, OJ EPO 1995, 605.

This document only referred to a one-stage process. The oxidation of propene to acrylic acid was only mentioned once, whereas acrolein was not even mentioned at all. This document dealt with the production of phthalic anhydride from o-xylene almost exclusively. Therefore, this document did not destroy novelty.

Apart from that, document (10) failed anyway to suggest the purposeful addition of high heat capacity inert diluent gases in order to affect the performance of the propene oxidation process to acrolein and acrylic acid, since it referred particularly to the oxidation of o-xylene. The carbon dioxide participated in the reaction and thus was not an inert diluent gas as required in the claimed invention. Therefore, it could not render the claimed invention obvious.

D. The overoxidation addressed in document (5) was not equivalent to a reduction of the selectivity in the formation of acrolein/acrylic acid due to the combustion of desired products to carbon dioxide and carbon monoxide. A comparison of the results of the examples 11 to 14 of the patent in suit showed that there was no clear relationship between the percentages, i.e. the yield, of the desired products recovered, on the one hand, and carbon dioxide/monoxide, on the other. In view of document (5), the substitution of a diluent gas, having a heat capacity above 8 cal/K, for steam was not an unavoidable choice, since this document taught a different alternative, i.e. to use a diluted catalyst.

Document (3) taught to prefer steam as diluent gas and, as its substitute, nitrogen. Carbon dioxide and saturated hydrocarbons were only examples of diluent gases which might be used. This document taught neither a minimum heat capacity of the diluent gas of 8 calories/gram-mole (°C), nor the enhanced yield of acrolein and acrylic acid which resulted therefrom, instead, it taught the independence of the yield of unsaturated acids from the nature of the diluents.

In conclusion, an ordinary expert, upon reading the documents in their entirety without hindsight, would not have been led to combine the documents in order to arrive at the claimed invention.

Document (4) preferred steam as diluent gas (cf. claim 7) and, in contrast to the patent in suit, used huge amounts of steam in the examples. This document therefore did not point to the claimed process.

E. With regard to the catalyst used in the examples of the patent in suit, it was clearly stated on page 7, lines 2 to 5, that commercial catalysts were used, the metals contained in the catalyst being indicated. In any case, the process of the patent in suit did not depend on any particular catalyst as specified in the patent specification on page 5, lines 12 and 13. If the Appellant were inclined to contradict this finding, then the onus of proof would rest with him. Therefore the results of the examples given in tables I and II of the patent in suit were to be taken into account for support of inventive step.

The experiments carried out according to the patent in suit were statistically designed, cf. page 7, lines 11 and following, in contrast to those conducted by the Appellant. Therefore the former experiments were pertinent and clearly showed a definite, statistically significant enhancement in the yield of acrolein and acrylic acid with increasing heat capacity of the diluent gas. If anything, the experiment conducted by the Appellant supported inventive merit associated with the claimed process, in that a higher yield of acrolein and acrylic acid was obtained when a higher heat capacity diluent was employed.

VIII. The Appellant requested that the decision under appeal be set aside and the patent be revoked.

The Respondent requested that the appeal be dismissed.

IX. At the end of the oral proceedings the decision of the Board was given orally.

Reasons for the Decision

1. The appeal is admissible.

2. *Late-filed facts and evidence (Article 114(2) EPC)*

2.1 Document (10) is new evidence cited for the first time in the Appellant's letter dated 25 January 1995 and has so far been relied upon in neither the opposition nor the appeal proceedings. No reasons have been given for this very late filing. Furthermore, whilst the Respondent has provided comments on this document in his letters dated 20 April 1995 and 28 November 1995, he objected to its introduction into the appeal

proceedings by reason of its late filing and its lack of relevance. New evidence should only very exceptionally be admitted into the proceedings before the Boards of Appeal, if it is *prima facie* highly relevant in the sense that it is highly likely to prejudice the maintenance of the European patent in suit (see decisions T 1002/92, OJ EPO 1995, 605, point 3.4 of the reasons; T 39/93, OJ EPO 1997, 134, point 3.1.2 of the reasons). This view is in line with the decision T 1016/93 (see point VI C above) cited by the Appellant in support of his request to admit that document into the appeal proceedings, since that decision also links the introduction of new documents to their *prima facie* high relevance.

The disclosure of document (10) goes beyond the factual framework of the proceedings thus far. It refers primarily to an oxidation process of o-xylene to phthalic anhydride (cf. page 1, lines 49 to 51; example) and *inter alia* to an oxidation process of propene to acrylic acid; however, no two-stage process producing in a first stage primarily acrolein is disclosed in the document, which is therefore *prima facie* not highly relevant with regard to novelty.

The carbon dioxide disclosed in document (10) and referred to by the Appellant is itself able to act as an oxidizing agent (cf. page 2, lines 104 to 106) and is thus not inert, whereas in the process claimed in the patent in suit an inert gas is used. The Appellant's allegation during the oral proceedings that carbon dioxide was nevertheless inert, since its concentration remained unchanged in the circulating gas during the oxidation process, which was based on page 3, lines 54 to 57, is not supported by the facts. The passage referred to by the Appellant relates to the concentration of carbon **mon**oxide, not of carbon

dioxide. Furthermore, in contrast to the patent in suit, the technical findings taught in document (10) are associated with the oxidation of o-xylene to phthalic anhydride (page 1, lines 99, 100; page 2, line 128 to page 3, line 31), and not with the oxidation of propene to acrylic acid. From the above it follows that document (10) is *prima facie* not highly relevant with respect to inventive step, either.

Consequently, the Board decides to disregard document (10) in the appeal proceedings pursuant to Article 114(2) EPC.

2.2 Document (11) is new evidence cited in the Appellant's letter dated 1 March 1996 for the first time. It reflects common general knowledge, and the Respondent raised no objections to its introduction into the appeal proceedings for its late filing. Consequently, applying the principle of "*volenti non fit injuria*", the Board is empowered to admit late-filed evidence, e.g. documents, into the appeal proceedings to which no objection was made by the Patentee, i.e. the Respondent (see decision T 39/93, OJ EPO 1997, 134, point 3.4 of the reasons). Therefore, this document is admitted into the proceedings.

2.3 The same conclusion applies to the further evidence, i.e. the reports of tests carried out in analogy to examples in the specification of the patent in suit, provided by the Appellant in his letters dated 3 July 1995 and 1 March 1996, since the Respondent raised no objection in this respect. Therefore, these test reports are admitted into the proceedings as well.

3. *Amendments (Article 123(2) and (3) EPC)*

The Respondent has amended claims 1 and 2 to require a lower limit of the composite heat capacity of 8 calories/gram-mole (°C) in the first stage. Claim 3 of the application as filed discloses a range of 8 to 20 calories/gram-mole (°C). The endpoint of 8 being specifically named, this restriction does not represent any new subject-matter within the meaning of Article 123(2) EPC (see decision T 2/81, OJ EPO 1982, 394, point 3 of the reasons).

The rise of the minimum composite heat capacity from 6.5 calories/gram-mole (°C) in claims 1 and 2 as granted to 8 calories/gram-mole (°C) in these claims as amended brings about a restriction of the scope of the claims and, therefore, of the protection conferred, which is in keeping with the requirements of Article 123(3) EPC.

Therefore, all the amendments made to the claims as granted comply with the requirements of Article 123(2) and (3) EPC.

4. *Novelty*

4.1 Document (6) refers to a process for oxidizing propene to primarily acrolein, i.e. to the first stage of the oxidation process of the patent in suit (claim 1; page 1, paragraph 2; examples). The passage on page 6, line 35, to page 7, line 8 of the document relates to this stage of the process; the passage on page 7, lines 8 to 13, contains a general reference to a second stage in case that acrylic acid is to be produced. That document discloses the optional feature to partly or completely substitute a mixture of oxygen and the diluent gases nitrogen, carbon dioxide or

steam for the air contained in the starting gas mixture, and the optional feature to partly or completely substitute nitrogen or carbon dioxide for the steam optionally contained in the starting gas mixture. The Appellant alleged that this general disclosure amounted to the disclosure of the particular combination of a two-stage process for producing acrylic acid using exclusively carbon dioxide as diluent gas. Since carbon dioxide has a heat capacity above 8 calories/gram-mole (°C), this disclosure was equivalent to the process claimed in the patent in suit according to the Appellant.

This particular combination, however, results from a multiple selection within the above-mentioned numerous optional and alternative features. In the absence of any pointer to said particular combination, that combined selection of features does not, for the skilled person, emerge clearly and unambiguously from document (6)(see for example decision T 653/93, point 3.2 of the reasons, not published in OJ EPO). Therefore, the particular combination of a two-stage process using exclusively carbon dioxide, as covered by claim 1 of the patent in suit, is not disclosed in document (6).

In addition, document (6) nowhere explicitly discloses to utilize a recycle stream in the preparation process. This has also been agreed by the parties. The Appellant's argument that, for economic reasons, the skilled person would infer the use of a recycling stream when reading document (6), refers to considerations relevant to the evaluation of obviousness, i.e. to the matter of inventive step, rather than to that of novelty. The assessment of patentability, however, calls for a clear distinction

between the respective requirements pertaining to novelty and inventive step. The feature specified in claim 1 of the patent in suit that one or more recycle streams are utilized is therefore not disclosed in document (6).

From the above it follows, in the Board's judgement, that document (6) does not anticipate the subject-matter of the patent in suit.

4.2 Document (3) refers to a process for preparing acrylic acid by oxidation of propene. According to page 2, paragraph 1 of that document, it is generally known in the art that such an oxidation process may be carried out either in one stage or in two stages. In the preparation process as disclosed in all examples of document (3), the oxidation of propene to acrylic acid is carried out directly without any intermediate process stage; the sole objective of that process is to prevent the formation of any intermediate aldehyde (cf. page 2, paragraph 3). The process disclosed in document (3) is therefore a one-stage process. The Appellant conceded that this document does not explicitly disclose a two-stage process, but he alleged that the two-stage character of the oxidation process in question was inherently disclosed, since the oxidation proceeded via the intermediate acrolein. This argument, however, refers to the reaction mechanism of the oxidation of propene to acrylic acid, but not to the stages of the preparation process as such. The state of the art clearly distinguishes between one- and two-stage processes, irrespective of the reaction mechanism involved. In the Board's judgement, document (3) neither explicitly nor implicitly discloses a two-stage process as required in claim 1 of the patent in suit.

Document (3) nowhere explicitly discloses to utilize a recycle stream in the preparation process. On the contrary, it is stated on page 2, last paragraph, that the aim of the invention is precisely to provide a process wherein recycling of intermediate aldehydes is not necessary. This advantage is emphasized furthermore on page 6, paragraph 2, where it is stated that it is not necessary to recycle the intermediate products of the oxidation. The Appellant's argument that the skilled person would, however, infer in document (3) the use of a recycle stream, is not supported by any fact; the argument refers to considerations relevant to the evaluation of obviousness, i.e. to the matter of inventive step, rather than to that of novelty. The feature of utilizing a recycle stream specified in claim 1 of the patent in suit therefore lacks disclosure in document (3).

In the Board's judgement, document (3) thus does not anticipate the subject-matter of the patent in suit. This view was no longer contested by the Appellant during oral proceedings, with the consequence that he no longer based his novelty objection on that document.

4.3 The Board is satisfied that the subject-matter of the patent in suit is not disclosed in any further prior art documents cited. Since this was not in dispute between the parties during appeal proceedings, and since the Opposition Division has already acknowledged novelty for the present claims, it is not necessary to give detailed reasons for this finding.

4.4 For the above reasons, the Board concludes that the subject-matter of the patent in suit is novel and meets the requirements of Articles 52(1) and 54 EPC.

5. *Inventive step*

5.1 In accordance with the "problem-solution approach" consistently applied by the Boards of Appeal to assess inventive step, the closest state of the art being the starting point is to be established in a first step. In this context, the Boards of Appeal developed certain criteria that should be adhered to. One such criterion is that the "closest prior art" is normally a prior art document disclosing subject-matter aiming at the same objective as the claimed invention and having the most relevant technical features in common (see decisions T 686/91, point 4 of the reasons; T 482/92, point 4.1 of the reasons; T 298/93, point 2.2.2 of the reasons; none published in OJ EPO).

5.2 The patent in suit refers to a two-stage oxidation process of propene to acrolein in a first stage and of acrolein to acrylic acid in a second stage. The objectives to be achieved, as indicated in the patent in suit, consist in reducing the waste water load in this process, and in improving the selectivity and the yield of this process by minimizing by-products and by maximizing the output of desired products (cf. patent specification page 2, lines 36, 39, 41; page 3, lines 44 to 46; page 4, lines 14, 23, 24). In relation to these objectives and to the relevant technical features in common, a selection among the documents cited in the proceedings must be made as to which is to be treated as the "closest prior art".

5.2.1 Document (2) refers to a two-stage oxidation process of propene to acrolein in a first stage and of acrolein to acrylic acid in a second stage (claim 10, page 1, paragraph 1). The off-gas from the process is recycled and is the preferred diluent gas (page 9, lines 6 to 8). This process is exemplified in

example 31, wherein the diluent gas, being primarily nitrogen, has in both stages - uncontested by the parties during appeal proceedings - a composite heat capacity of not below 7.11 calories/gram-mole (°C) (cf. decision under appeal point 3 of the reasons). Steam is not added to the diluent gas in the first stage.

The objectives addressed in document (2) consist in reducing the water load in this process by abstaining from the use of steam, thus making unnecessary the subsequent removal of water (page 3, paragraph 2, last sentence), and in improving the conversion rate of the reactants and the selectivity to the desired products in this process (page 3, paragraph 2, first sentence; page 7, paragraph 2, first sentence).

Thus, document (2) aims at the same objectives as the claimed invention and has all relevant technical features in common, except for the feature that the composite heat capacity of the diluent gas in the first stage amounts to at least 8 calories/gram-mole (°C).

5.2.2 Document (1) refers to a two-stage oxidation process of propene to acrolein in a first stage and of acrolein to acrylic acid in a second stage (claim, example 1). That process comprises the technical features of the process disclosed in document (2), even though the former uses steam in the first stage in an amount within (example 1) or outside (example 2) the limit specified in the patent in suit. The objective addressed in document (1), however, consists primarily in avoiding the combustion of acrolein after the first stage and the polymerisation of the reaction products by quenching the reaction gas with recycled off-gas and air, and in improving the yield and the selectivity of acrylic acid (page 7, paragraph 2).

Thus, in contrast to document (2), document (1) does not aim at the objective, indicated in the patent in suit, of reducing the water load, and it does not point to the relevant feature of reducing in the first stage the amount of steam below the limit specified in the patent in suit. The Board concludes therefore that document (1) represents prior art being further away from the patent in suit than document (2).

5.2.3 Document (5) refers to a two-stage oxidation process of propene to acrolein in a first stage and of acrolein to acrylic acid in a second stage (claim 1, page 1, paragraph 1). The off-gas from the process is recycled, and the diluent gas in the first step comprises, according to all examples, steam in an amount exceeding the upper limit indicated in the patent in suit. The objective consists in avoiding overoxidation and explosive combustion processes and in improving the space-time-yield (page 3, paragraph 2).

Thus, document (5) does not aim at the objectives indicated in the patent in suit and does not specifically disclose the relevant technical feature of reducing the amount of steam in the first stage below the limit indicated in the patent in suit. Therefore, it cannot represent the closest prior art.

5.2.4 Document (6) refers to an oxidation process of propene to primarily acrolein (claim 1; page 1, paragraph 2; examples), i.e. only to the first stage of the oxidation process of the patent in suit. A general reference to a second process stage in case acrylic acid is to be produced, contained in document (6) on page 7, lines 8 to 13, does not alter the fact that the teaching of this document is directed to the first stage of the oxidation process. Documents (3) and (4) refer to a one-stage process, not to a two-stage

process for producing acrylic acid, cf. point 4.2 above. Therefore, these documents relate to embodiments different to the subject-matter of the patent in suit and cannot represent the closest state of the art.

5.2.5 For these reasons, in the Board's judgement, document (2) represents the prior art closest to the patent in suit and the starting point in the assessment of inventive step.

5.3 In the next step the technical problem which the invention addresses in the light of the closest state of the art is to be determined.

The technical problem as indicated in the patent in suit consists in reducing the waste water load in the process and in improving the selectivity and yield of the process (cf. patent specification page 2, lines 36, 39, 41; page 3, lines 44 to 46; page 4, lines 14, 23, 24). The process of document (2), representing the closest prior art, abstains from adding steam to the diluent gas in the first stage of the process in order to reduce the water load. In the light of that document, the technical problem of reducing the water load no longer applies; therefore, the problem underlying the patent in suit boils down to improving the selectivity and the yield of the process.

5.4 The patent in suit suggests, as the solution to this problem, to use in the first stage of the process an inert diluent gas having a composite heat capacity of at least 8 calories/gram-mole (°C) (cf. patent specification page 3, lines 47, 48; page 4, lines 13, 23; see point IV above).

5.5 The Appellant and the Respondent were divided on the matter whether the evidence provided convincingly demonstrates that the proposed solution successfully solves the problem underlying the patent in suit.

5.5.1 The specification of the patent in suit indicates on pages 10 and 12, tables I and II, the results, i.e. the yield and the conversion rate, of examples according to the invention and of comparative examples.

5.5.1.1 In table I, examples 1 to 7 are comparative, since either the composite heat capacity of the diluent gas in the first stage is below the minimum limit of 8 calories/gram-mole (°C) or the amount of steam above the upper limit of 0.4 mole of steam per mole of propene; by way of contrast, example 8 is in accordance with the invention, since the composite heat capacity is above the minimum limit and no steam is used. Comparative example 4 is the only one in table I not to use steam and to show a composite heat capacity below 8 calories/gram-mole (°C); it is therefore the only one to be able to reflect the impact of the solution suggested by the patent in suit (see point 5.4 above) on the results indicated, i.e. yield and conversion rate, when comparing with example 8. However, discrepancies are to be noticed between examples 4 and 8 with regard to the reaction parameters "space velocity" - 1562.2 hr^{-1} in example 8 versus 1585.1 hr^{-1} in example 4 - and "reactor bath temperature" - 324.4 °C in example 8 versus 314.5 °C in example 4. Both reaction parameters have also a strong impact on the results indicated; therefore, the comparison of the results of example 8 with those of comparative example 4 does not truly reflect the impact exclusively of the solution suggested by the

patent in suit, i.e. a composite heat capacity of at least 8 calories/gram-mole (°C), but is biased and rendered unfair by the discrepancies in the other reaction parameters. This specific comparison of examples is thus not to be taken into account.

5.5.1.2 In table II, examples 9 and 11 are comparative, since in both cases the composite heat capacity of the diluent gas in the first stage is below the minimum limit of 8 calories/gram-mole (°C), and in example 9 the amount of steam is above the upper limit of 0.4 mole of steam per mole of propene; examples 10 and 12 to 14 are in accordance with the invention, since the composite heat capacity is above the prescribed minimum limit and no steam is used. Comparative example 11 is the only one in table II not to use steam and to show a composite heat capacity below 8 calories/gram-mole (°C); it is therefore the only one to be able to reflect the impact of the solution suggested by the patent in suit (see point 5.4 above) on the results indicated, i.e. yields and conversion rate, when comparing with examples 10 and 12 to 14.

There are discrepancies to be noticed between comparative example 11, on the one hand, and examples 10 and 14, on the other, with regard to the reaction parameters "space velocity" - 1380 hr^{-1} in example 14 versus 1600 hr^{-1} in example 11 - and "reactor bath temperature" - 330 °C in example 10 versus 320°C in example 11. Both reaction parameters have also a strong impact on the results indicated; therefore the comparison of the results of examples 10 and 14 with those of comparative example 11 does not truly reflect the impact exclusively of the solution

suggested by the patent in suit but is biased and rendered unfair by the discrepancies in the other reaction parameters. The comparison of examples 10 and 14 with comparative example 11 is thus not to be taken into account.

However, examples 12 and 13, according to the invention, and comparative example 11 are distinguished from one another exclusively by their composite heat capacity of the diluent gas. Therefore, the results indicated in these examples truly reflect the impact precisely of the solution suggested by the patent in suit on the basis of a comparison with a diluent gas predominantly composed of nitrogen, i.e. a proper comparison with the closest state of the art as set out in point 5.2.1 above. This specific comparison of examples is thus fair and to be taken into consideration.

5.5.1.3 The Appellant argued that the results of the examples contained in tables I and II of the specification of the patent in suit should be disregarded in the assessment of inventive step since he was not in a position to verify these results, because the catalysts used therein were not specified.

However, the metals which were comprised in the catalyst used in the examples are indicated, and the catalyst used is specified as being a commercial one (cf. patent specification page 7, lines 2 to 5). In any case, the process of the patent in suit is independent of any particular catalyst as indicated explicitly in the patent specification on page 5, lines 12 and 13. Consistently therewith, independent claim 1 as well as all dependent claims of the patent

in suit are silent about any specific catalyst to be used. Therefore, the Appellant's objection is not pertinent, with the consequence that the results of the examples objected to are with good reason to be taken into consideration when assessing inventive step.

5.5.2 In the letters dated 3 July 1995 and 1 March 1996, the Appellant has provided test reports. The examples (a) to (d) contained therein have been carried out under identical reaction conditions, keeping the conversion rate constant and using no steam; only the composite heat capacity of the diluent gas in the first stage has been varied. In the examples (a), (b) and (d), the heat capacity is that of examples 10, 12 and 13 of the patent in suit, i.e. above the lower limit of 8 calories/gram-mole (°C). These examples are therefore in accordance with the invention. In the example (c), the heat capacity is that of example 4 of the patent in suit, i.e. below the lower limit; this example is therefore a proper comparative one. The results indicated therein, i.e. the selectivity, truly reflect the impact of the sole essential feature of the solution suggested by the patent in suit, i.e. the minimum heat capacity of the diluent gas of 8 calories/gram-mole (°C). This specific comparison of examples is, thus, fair and to be taken into consideration in addition to those indicated in point 5.5.1.2 above.

5.5.3 Having regard to the technical problem of improving the yield of the process, the examples in table II of the patent in suit indicate the overall yield of the desired products (acrolein plus acrylic acid).

Examples 12 and 13 according to the invention show a yield of 93.29 % and 93.96 % respectively, and comparative example 11 shows a yield of 89.31 %. These results demonstrate that, in fact, the yield of the process is improved.

5.5.4 With regard to the technical problem of improving the selectivity of the process, the examples in table II of the patent in suit do not explicitly indicate this result. Since yield is the mathematical product of selectivity and conversion rate, the selectivity can be calculated, provided the yield and the conversion rate are known. Yield and conversion rate are indicated in table II. The Appellant has calculated the corresponding selectivity in his letter dated 3 July 1995, on page 4. Examples 12 and 13 according to the invention show a selectivity having regard to (acrolein plus acrylic acid) of 96.5 mol % and 95.6 mol % respectively, and comparative example 11 shows a selectivity of 94.0 mol %. These results demonstrate that in fact the selectivity of the process is improved.

The Appellant's own examples (a), (b) and (d) according to the invention show a selectivity with regard to (acrolein plus acrylic acid) of 92.2 mol %, 93.1 mol % and 93.2 mol % respectively, and comparative example (c) shows a selectivity of 92.1 mol %. These results demonstrate likewise that the selectivity of the process is improved. During oral proceedings the Appellant accepted that the effect of improving selectivity is indeed achieved and is particularly distinct when using gases having a composite heat capacity well above the minimum of 8 calories/gram-mole (°C).

5.5.5 The Appellant objected that, in order to be convincing, a comparison of yields required identical conversion rates; if this were not the case, the yields should be standardized on the basis of a constant conversion rate, i.e. the selectivity, in order to render the comparison objective. A fair comparison of selectivities required identical conversion rates, too.

Irrespective of whether or not the Appellant's allegation is correct, it is not supported by the facts. The yield has been standardized on the basis of a conversion rate, and the corresponding selectivity has been indicated (see point 5.5.4, paragraph 1 above) and measured on the basis of a constant conversion rate (see points 5.5.2 and 5.5.4, paragraph 2 above). Therefore, the Appellant's objection does not convince the Board.

Furthermore, the Appellant objected that the calculated selectivity between the examples and the comparative examples of the patent in suit could hardly be distinguished and that it was within the scope of measuring inaccuracy. On the one hand, the Appellant failed to quantify any measuring inaccuracy and to provide any evidence for it. On the other hand, the selectivity increases by 1.6 % and 2.5%, respectively, between the examples according to the invention and the comparative example as set out in point 5.5.4, paragraph 1 above. This increase is larger than any likely measuring inaccuracy; it is also significant since the achievement of even a numerical small improvement of the present process used on a large scale represents a worthwhile effect which must not be disregarded in assessing inventive step (see decision T 38/84, OJ EPO 1984, 368). Therefore, the Appellant's objection is to be rejected.

5.5.6 To conclude, in the Board's judgement, the evidence on file convincingly demonstrates that an improvement of the selectivity and the yield of the claimed process has successfully been achieved and that the improvement is due to the composite heat capacity of the diluent gas of at least 8 calories/gram-mole (°C), i.e. the solution proposed by the patent in suit.

5.6 In the last step according to the "problem-solution approach", the obviousness of the proposed solution to the problem underlying the patent in suit is to be examined in view of the further state of the art.

5.6.1 Document (3) discloses on page 5, paragraph 3, a list of examples for diluent gases to be used in a one-stage oxidation process of propene to acrylic acid. This list consists of nitrogen, steam, carbon dioxide and saturated hydrocarbons. The heat capacity of nitrogen is below, and that of the other gases is above, the limit of 8 calories/gram-mole (°C); their heat capacities are, however, not indicated in the document and not suggested as being critical. The document teaches that the yield of the desired acrylic acid is quite independent from the nature of the diluent gas. When using steam, the amount of the by-product acetic acid is increased, with the consequence that nitrogen should substitute for steam if the amount of acetic acid is to be limited.

Therefore, document (3) does not give any incentive to improve the selectivity and the yield of the process by choosing diluent gases having a heat capacity of at least 8 calories/gram-mole (°C). Moreover, that document even points away from the invention: the nature of the diluent gas is taught not to be

essential for the yield, and nitrogen, which has a heat capacity below the required minimum limit, is a preferred diluent gas. Thus, document (3) does not render obvious the proposed solution to the problem underlying the patent in suit.

5.6.2 The same conclusion applies to document (4) which refers to a one-stage oxidation process of propene to acrylic acid in the presence of particular catalysts. This document discloses on page 5, paragraph 2, the optional use of the inert diluent gases carbon dioxide, nitrogen, saturated hydrocarbons or steam. The heat capacity of nitrogen is below, and that of the other gases is above, the limit of 8 calories/gram-mole (°C); their heat capacities are, however, not indicated in the document and not suggested as being critical. Therefore, document (4) does not give any incentive to improve the selectivity and the yield of the process by choosing diluent gases having a heat capacity of at least 8 calories/gram-mole (°C). Moreover, it even points away from the invention; it teaches that preferably steam should be used as diluent gas (claim 7; page 5, paragraph 2) in huge amounts (claim 8; examples), which is in sharp contrast to the claimed process. Thus, document (4) does not render obvious the proposed solution to the problem underlying the patent in suit.

5.6.3 Document (5) refers to a two-stage oxidation process of propene to acrylic acid. The gist of this document is to start with a catalyst having low activity and to increase its activity up to the end of the process to prevent overoxidation (claim 1; page 3, paragraph 2). The control of the activity of the catalyst is performed by diluting the catalyst with inert material (page 4, last paragraph to page 5, last paragraph).

The document teaches on page 4, paragraph 2 that a further particular advantage is associated with the dilution of the catalyst: it prevents from the danger of overoxidation if recycled off-gas, having a lower heat capacity than steam, substitutes for steam as a diluent gas.

The parties had conflicting views as to whether or not the problem of preventing overoxidation was tantamount for the skilled person to the problem of improving the selectivity in the process, which is part of the problem underlying the patent in suit, and whether or not he was given an incentive to choose diluent gases having a heat capacity above 8 calories/gram-mole (°C). However, irrespective of whether or not the problem of preventing overoxidation is to be understood as tantamount to the problem of improving selectivity, the conclusion is the same.

If the problem of preventing overoxidation is not regarded as tantamount to the problem of improving the selectivity in the process, then the problem underlying the patent in suit is not addressed in document (5). Consequently, it cannot give any hint to its solution.

If the problem of preventing overoxidation is regarded as tantamount to the problem of improving the selectivity in the process, then the problem underlying the patent in suit (see point 5.3 above) is addressed in document (5). However, the solution to this problem proposed in document (5) is different to that proposed in the patent in suit. Indeed, document (5) proposes to control the activity of the catalyst by diluting the catalyst with inert material, whereas the patent in suit suggests to use a diluent gas having a heat capacity above 8 calories/gram-mole (°C). To assume that, against the teaching of

document (5), the skilled person would nevertheless not dilute the catalyst and not control its activity in order to solve the problem of preventing overoxidation, amounts to a distortion of the explicit teaching of that document. It appears that the Appellant's view is based on hindsight with the knowledge of the present invention, which the Board cannot sanction.

Thus, document (5) does not render obvious the solution proposed to the problem underlying the patent in suit.

5.6.4 The Appellant did not rely on further documents in order to object to obviousness. The Board is satisfied that none of the other documents cited in the proceedings renders the proposed solution obvious. Document (1) teaches to quench the reaction gas with recycled off-gas and air, whereas document (6) relates to particular catalysts; none of these documents refers to the heat capacity of the diluent gases.

5.7 For these reasons the Board concludes that the subject-matter of claim 1, and by the same token, that of dependent claims 2 to 9, involves an inventive step within the meaning of Articles 52(1) and 56 EPC.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

E. Görgmaier A. Nuss