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Datasheet for the decision of 06 June 2012

Case Number: T 0314/09 - 3.3.01

Application Number: 02804719.9

Publication Number: 1453818

IPC: C07D 301/14

Language of the proceedings: EN

Title of invention:
Process of preparing an olefin oxide from olefin and organic hydroperoxide

Patentee:
Dow Global Technologies LLC

Opponents:
REPSOL YPF S.A.
Shell Internationale Research Maatschapij B.V.

Headword:
Olefin expoxidation/DOW

Relevant legal provisions:
EPC Art. 100(a), (b)

Relevant legal provisions (EPC 1973):
-

Keyword:
"Inventive step (no) - obvious alternative process"

Decisions cited:
T 0197/86

Catchword:
-

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Case Number: T 0314/09 - 3.3.01

D E C I S I O N
of the Technical Board of Appeal 3.3.01
of 06 June 2012

Appellant: (Patent Proprietor)
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Decision under appeal: **Decision of the Opposition Division of the European Patent Office posted 20 November 2008 revoking European patent No. 1453818 pursuant to Article 101(3)(b) EPC.**

Composition of the Board:

Chairman: P. Ranguis
Members: C. M. Radke
C.-P. Brandt

Summary of Facts and Submissions

I. The patentee has appealed against the decision of the opposition division posted on 20 November 2008 by which the European patent no. 1 453 818 was revoked.

II. The patent in suit relates to a process for preparing an olefin oxide by reacting an olefin with an organic hydroperoxide.

III. Oppositions had been lodged by Repsol YPF S.A. (hereinafter called respondent I) and Shell Internationale Research Maatschappij B.V. (respondent II).

Both oppositions were directed against the patent as a whole and were based on grounds under Article 100(a) (novelty and inventive step), (b) and (c) EPC.

IV. The following documents were inter alia cited during the opposition procedure:

(D1) US-A-5 410 077
(D2) WO-A-99/32 469
(D3b) O. Levenspiel, Chemical Reaction Engineering, 3rd edn., John Wiley & Sons, New York/US, 1999, 126-128
(D4) C. G. Hill, Jr., An Introduction to Chemical Engineering Kinetics & Reactor Design John Wiley & Sons, New York/US 1977, 405-406
(D10) GB-A-1 218 560
(D11) GB-A-1 114 896.

V. The opposition division considered the subject-matter of the claims then on file not to involve an inventive step in view of the disclosure of document (D11).

VI. The present claims are

claims 1 to 20 of the main request,
claims 1 to 19 of auxiliary request I;
claims 1 to 18 of auxiliary request II;
claims 1 to 20 of auxiliary request III;
claims 1 to 19 of auxiliary request IV;
claims 1 to 18 of auxiliary request V;
all submitted with the letter dated 7 May 2012, and

claims 1 to 18 of auxiliary request VI, submitted during the oral proceedings of 6 June 2012.

(a) The only independent claim of the main request reads as follows:

"1. A process of preparing an olefin oxide and a co-product alcohol comprising contacting an olefin and an organic hydroperoxide in a liquid phase in the presence of homogeneous epoxidation catalysts under process conditions sufficient to prepare the olefin oxide and the corresponding alcohol; the contacting being conducted in a reactor system designed to facilitate plug flow behaviour of the liquid phase; the reactor system further providing for the staged addition of organic hydroperoxide such that a primary organic hydroperoxide feedstream is split into a plurality of split organic hydroperoxide feedstreams, and the split organic hydroperoxide feedstreams are distributed

among reaction zones, or reactors, or both, in the reactor system, wherein the organic hydroperoxide is ethylbenzene hydroperoxide."

(b) The only independent claim of the auxiliary request I reads as follows (where amendments with respect to claim 1 of the main request are marked in bold):

"1. A process of preparing an olefin oxide and a co-product alcohol comprising contacting an olefin and an organic hydroperoxide in a liquid phase in the presence of homogeneous epoxidation catalysts under process conditions sufficient to prepare the olefin oxide and the corresponding alcohol; the contacting being conducted in a reactor system designed to facilitate plug flow behaviour of the liquid phase; the reactor system further providing for the staged addition of organic hydroperoxide such that a primary organic hydroperoxide feedstream is split into a plurality of split organic hydroperoxide feedstreams, and the split organic hydroperoxide feedstreams are distributed among reaction zones, or reactors, or both, in the reactor system, wherein the organic hydroperoxide is ethylbenzene hydroperoxide,

and wherein a reactor system is employed comprising one or more reactors, each reactor being divided into 4 or more reaction zones; and wherein if a multi-reactor system is employed, the reactor system comprises greater than 2 and less than 12 sequentially interconnected reactors."

(c) The only independent claim of the auxiliary request II reads as follows (where amendments with respect to claim 1 of the main request are marked in bold):

"1. A process of preparing an olefin oxide and a co-product alcohol comprising contacting an olefin and an organic hydroperoxide in a liquid phase in the presence of homogeneous epoxidation catalysts under process conditions sufficient to prepare the olefin oxide and the corresponding alcohol; the contacting being conducted in a reactor system designed to facilitate plug flow behaviour of the liquid phase; the reactor system further providing for the staged addition of organic hydroperoxide such that a primary organic hydroperoxide feedstream is split into a plurality of split organic hydroperoxide feedstreams, and the split organic hydroperoxide feedstreams are distributed among reaction zones, or reactors, or both, in the reactor system, wherein the organic hydroperoxide is ethylbenzene hydroperoxide,

and wherein a reactor system is employed comprising one or more reactors, each reactor being divided into 4 or more reaction zones; and wherein if a multi-reactor system is employed, the reactor system comprises greater than 2 and less than 12 sequentially interconnected reactors

wherein per reactor, 3 or more baffles are employed."

(d) Claim 1 of auxiliary requests III, IV and V read as those of the main request and of auxiliary requests I and II, respectively, with the exception that the term

"so as to reduce back-mixing of the liquid phase;"

was inserted between "the contacting being conducted in a reactor system designed to facilitate plug flow behaviour of the liquid phase" and "the reactor system further providing for the staged addition of organic hydroperoxide ...".

(e) The claims of auxiliary request VI only differ from those of auxiliary request I in that

- the full stop at the end of the claim was replaced by ", wherein the olefin is propylene.",
- claim 2 was deleted and the subsequent claims renumbered accordingly.

VII. The arguments of the appellant (patentee) as far as they are relevant for this decision may be summarised as follows:

The respondent had not shown that the invention could not be carried out. It was evident from the description and the examples of the patent in suit as well as from the standard text books (D3b) and (D4) how the ideal situation of plug flow could be approached.

The subject-matter claimed differed from that disclosed in document (D11) in that ethylbenzene hydroperoxide was used and a reactor system that was designated to facilitate plug flow. These differences solved the problem of providing a high epoxydation rate, a good conversion and a high selectivity. Although no explicit comparative tests with respect to document (D11) were on file, a comparison between example 1 of document (D11) and the examples of the patent in suit showed that these problems were solved. Document (D11) did not suggest plug flow. Whereas a jacketed tubular reactor was used in example 1 of document (D11), the process disclosed in document (D10) required a different reactor system due to the fact that in this process volatile components of the reaction mixture had to be distilled off. Consequently, the person skilled in the art had no motivation to modify the reactor used in example 1 of document (D11) according to the teaching of document (D10). Therefore, the subject-matter of the claims involved an inventive step. The additional features of claim 1 of auxiliary requests I to V specified the reactor systems facilitating plug flow. The restriction to the oxidation of propylene in auxiliary request VI further distinguished the subject-matter claimed from that disclosed in examples 2 and 3 of document (D11).

VIII. Respondent I deemed that the person skilled in the art could not carry out the invention as far as the reactor design "to facilitate plug flow behaviour" was concerned. As plug flow was an ideal situation which could not be achieved in practice and as the appellant considered the tubular reactor used in example 1 of document (D11) not to facilitate plug flow, the skilled

person did not know what fell under the scope of the claims.

Respondent I did not maintain its objection based on grounds under Article 100(c) EPC.

Document (D11) could be considered to represent the closest prior art. Due to the absence of comparative examples, the problem to be solved could only be considered as to provide an alternative process. It argued that the solution defined in the present claims was not inventive because

- the process disclosed in example 1 of document (D11) only differed from the one claimed in the patent in suit in that cumene hydroperoxide was used instead of ethylbenzene hydroperoxide. However, ethylbenzene peroxide was mentioned as one of the few preferred hydroperoxides in said document;
- document (D10) - which was in the same field as the patent in suit - recommended to use of reaction vessels subdivided by baffles in order to prevent undesirable backmixing, and
- the use of propylene and ethylbenzene hydroperoxide was disclosed in both (D10) and (D11).

IX. The Appellant requested that the decision under appeal be set aside and the patent be maintained on the basis of the claims of the main request or those of any of the auxiliary requests I to V, all filed with the letter dated 7 May 2012, or on the basis of the claims of auxiliary request VI submitted at the oral proceedings before the Board.

Respondent I requested that the appeal be dismissed.

X. Respondent II neither presented any arguments nor filed any requests during the appeal phase. As announced in its letter dated 15 May 2012, it did not attend the oral proceedings before the Board. Thus the oral proceedings were held in the absence of the duly summoned respondent II as settled in Rule 115(2) EPC.

XI. At the end of the oral proceedings the chairman announced the decision of the Board.

Reasons for the Decision

1. The appeal is admissible.

2. *Article 100(b) EPC*

It had to be decided whether or not the patent in suit enabled the skilled person to use "a reactor system designed to facilitate plug flow behaviour" in the framework of the claimed process.

The person skilled in the art knew what the term plug flow means (see, e.g., the textbook (D3b), page 126, the first sentence under the heading "Equal-Size Mixed Flow Reactors in Series").

According to the patent in suit, "plug flow involves the bulk forward movement of fluid flow from the entrance port to the exit port of the reactor, such that essentially all fluid elements have essentially

the same history (residence time) as they pass through the reactor." (see page 8, lines 39-41).

In fact, as agreed during the oral proceedings before the Board by both parties present, plug flow is the ideal behaviour of a fluid where **all** fluid elements have **exactly** the same residence time in the reactor. This means that there is absolutely no back-mixing of the fluid, a condition not fulfilled in real reactor systems.

Hence, it is apparent that the expression "designed to facilitate plug flow behaviour" in present claim 1 of each of the requests cannot mean that plug flow could be achieved by means of this design, but rather that it can be helpful to approach a fluid flow close to plug flow.

As reactor designs to facilitate plug flow behaviour, the patent in suit inter alia discloses a cascade of reactors, each equipped with baffles (see examples 1 and 2) and a tubular reactor system (see example 3).

For these reasons, the Board is satisfied that the patent in suit enables the person skilled in the art to use an appropriate design "to facilitate plug flow behaviour". In view of the outcome of this decision, it is not necessary to give more detailed reasons.

3. *Inventive step*

3.1 Main request

3.1.1 The closest prior art

Both the appellant and respondent I considered document (D11) as the closest prior art.

This document discloses in example 1, the epoxidation of propylene with cumene hydroperoxide in an elongated tubular reactor in the presence of molybdenum naphthenate as the homogeneous catalyst (see page 2, lines 79-91). Part of the hydroperoxide is fed into the reactor via line 2, the remainder via lines 3 and 4 at one third and two thirds of the length of the reactor tube (see figure 1 and page 3, lines 102-104).

The appellant argued that example 1 of document (D11) did not disclose a "reactor system designed to facilitate plug flow behaviour". However, the patent in suit shows in example 3 that a tubular reactor system can be "operated essentially under plug flow" (see page 11, lines 28-29 and point 2 above). Said example does not disclose any means other than the tubular form of the reactor as the design to facilitate plug flow. Therefore it is to be concluded the tubular form of the reactor used in example 1 of document (D11) is a design to facilitate plug flow behaviour".

In the general part of the description, document (D11) lists seven preferred hydroperoxides including ethylbenzene hydroperoxide (see page 2, lines 40-45).

Document (D11) thus discloses in example 1 the following essential features of claim 1 of the main request:

- the use of a homogeneous catalyst;
- a reactor design facilitating plug flow; and
- the staged addition of the hydroperoxide;

and the document lists ethylbenzene peroxide as one of the preferred hydroperoxides. For these reasons, document (D11) relates to a process which has more features in common with the one claimed in the patent in suit than the processes taught in any of the other prior art documents cited.

For these reasons, also the Board considers document (D11) as the closest prior art.

3.1.2 The problem

The problem and solution approach generally applied by the boards of appeal requires that the problem is defined which the claimed subject-matter solves in view of the closest prior art. This implies that those features contribute to the solution which distinguish the claimed invention from the respective disclosure in the closest prior art. If there is a feature which distinguishes the subject-matter of present claim 1 over the disclosure of document (D11) then it is the use of ethylbenzene hydroperoxide as the organic hydroperoxide.

Hence it has to be determined whether it is evident that this differing feature contributes to the solution of a specific technical problem. The appellant argued that a comparison between example 1 of document (D11)

with the examples of the patent in suit showed a surprising high conversion and selectivity of the claimed process (see under point VII above). Such a comparison can only be meaningful if it is "such that the effect is convincingly shown to have its origin in the distinguishing feature of the invention." (see T 197/86, OJ EPO 9/1989, 371, point 6.1.3 of the reasons). However, example 1 of document (D11) not only differs in the hydroperoxide used from the examples of the patent in suit, but, e.g., also in reaction temperature. In example 1 of document (D11), the reaction temperature is maintained at 90°C (see page 3, lines 106-107). In examples 1 and 2 of the patent in suit, a reaction temperatures of 111°C is reported, in example 3 one of 113°C. It cannot be excluded that this difference in reaction temperature and not the choice of hydroperoxide gives rise to the claimed effect. Hence, it has not been shown that the use of ethylbenzene hydroperoxide instead of cumene hydroperoxide solves a specific tecnical problem.

Therefore, the problem to be solved can only consist in the provision of an alternative process. The examples of the patent in suit show that this problem has been solved.

3.1.3 The solution

The most obvious way to look for an alternative process was to consider the alternatives suggested in the closest prior art as such. Due to the fact that document (D11) cites ethylbenzene hydroperoxide as one of the preferred peroxides, it was obvious for the person skilled in the art to modify the process

disclosed in example 1 of this document by replacing cumene hydroperoxide by ethylbenzene hydroperoxide, thus ending up with the subject-matter of claim 1. For this reason, claim 1 of the main request is not based on an inventive step.

The Board can only decide on a request as a whole. Hence, the main request as a whole was not deemed to be allowable.

3.2 Auxiliary requests I to V

3.2.1 The claims of these auxiliary requests differ from those of the main request in that they contain one or more of the following additional features (see under point VI above):

- "and wherein a reactor system is employed comprising one or more reactors, each reactor being divided into 4 or more reaction zones; and wherein if a multi-reactor system is employed, the reactor system comprises greater than 2 and less than 12 sequentially interconnected reactors"

- "wherein per reactor, 3 or more baffles are employed."

- "so as to reduce back-mixing of the liquid phase;".

3.2.2 There is no evidence on file showing that these features contribute to the solution of a specific technical problem in view of the process in a tubular reactor as disclosed in document (D11). Hence, the

problem posed and solved by the subject-matter of these claims remains the provision of an alternative process.

3.2.3 Document (D10) discloses the epoxidation of an olefinically unsaturated compound with an organic peroxide in the liquid phase. Propylene is the preferred olefin (see claim 7), ethylbenzene hydroperoxide the preferred organic peroxide (see claim 8).

This document mentions the following on page 4, lines 10-21 (emphasis added by the Board):
"Reactor 10 can be of the tubular type or, more suitably and as depicted in the attached drawing, can be a reaction vessel internally sub-divided by **baffles** 15 into a plurality of compartments 16. Alternatively, one or more of said compartments can be a separate reaction vessel. **This compartmentation of the reactor,** either **by internal baffles** or by provision of several reaction vessels connected in series, **provides a means for positively preventing undesirable back-mixing** of reaction products with the entering reactants."

3.2.4 The appellant was of the opinion that the person skilled in the art would not have considered document (D10) when making the invention starting from the disclosure of document (D11)(see under point VII above). This argument was based on the fact that in example 1 of document (D11) the tubular reactor was provided with a jacket to regulate the reaction temperature, whereas document (D10) discloses a process in which the reaction heat is removed by distilling off part of the reaction medium, which the appellant did not deem to be feasible in the presence of a jacket (see document

(D11), page 3, lines 104-106; see document (D10), claim 1 and page 1, lines 74-82).

This argument of the appellant does not take into account that the recommendation to avoid back-mixing given in document (D10) is a general one. This is so because there is no indication in document (D10) that the problem of back-mixing is specific to the process conditions disclosed there. Furthermore, it is evident that document (D10) suggests means for avoiding back-mixing which can also be applied to a process in which, as disclosed in document (D11), the reaction mixture is not distilled off the reactor.

Therefore, the person skilled in the art seeking to modify the process of document (D11) would have avoided back-mixing as suggested in document (D10). The latter document taught that the use of a cascade of reactors in series or the subdivision of the reactor by baffles would avoid back-mixing. The use of at least one reactor with at least three baffles per reactor thus is a trivial reactor design for the given purpose.

For these reasons, the subject-matter of claim 1 of each of the auxiliary requests I to V is not based on an inventive step.

As the Board can only decide on a request as a whole, auxiliary requests I to V could not be allowed.

3.3 Auxiliary request VI

The subject-matter of the claims of this request merely differs from the one of auxiliary request I by

specifying that the olefin is propylene (see under point VI(e) above). Propylene is the preferred olefin in documents (D10) and (D11) and is used in the example 1 of (D11) (see (D10), claim 7; and (D11), claim 4). Therefore, this additional feature does not contribute to the presence of an inventive step.

Consequently, auxiliary request VI was also refused.

4. Hence, grounds under Article 100(a) EPC prejudice the maintenance of the patent based on any of the requests on file.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

M. Schalow P. Ranguis