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**Datasheet for the decision
of 28 July 2023**

Case Number: T 0917/21 - 3.3.09

Application Number: 13865468.6

Publication Number: 2935163

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Language of the proceedings: EN

Title of invention:

CONTINUOUS ETHYLENE TETRAMERIZATION PROCESS

Patent Proprietor:

Nova Chemicals (International) S.A.

Opponent:

Sasol South Africa Limited

Headword:

Continuous Ethylene Tetramerization Process/NOVA CHEMICALS

Relevant legal provisions:

EPC Art. 100(a), 100(c), 56, 123(2)

Keyword:

Grounds for opposition - added subject-matter (yes)
Amendments - extension beyond the content of the application
as filed (yes)
Inventive step - main request (no) - auxiliary requests (no)

Decisions cited:



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Case Number: T 0917/21 - 3.3.09

D E C I S I O N
of Technical Board of Appeal 3.3.09
of 28 July 2023

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Decision under appeal: **Interlocutory decision of the Opposition
Division of the European Patent Office posted on
21 April 2021 concerning maintenance of the
European Patent No. 2935163 in amended form.**

Composition of the Board:

Chairman A. Haderlein
Members: C. Meiners
F. Blumer

Summary of Facts and Submissions

- I. This decision concerns the appeals filed by the patent proprietor and opponent against the opposition division's interlocutory decision finding that, on the basis of the auxiliary request 16 (then on file), the patent in suit (hereinafter "the patent") met the requirements of the EPC. As both parties are appellants, they will continue to be referred to as the patent proprietor and opponent.
- II. In its notice of opposition, the opponent had requested that the patent be revoked in its entirety based, *inter alia*, on the grounds for opposition under Article 100(a) EPC in combination with Article 56 EPC (lack of inventive step) and Article 100(c) EPC (added subject-matter).
- III. In its decision, the opposition division found, *inter alia*, that the subject-matter of auxiliary request 16 then on file involved an inventive step in view of both documents D1 and D3 as the closest prior art.
- IV. The following documents submitted by the parties are relevant to the decision:
- D1 S. Kuhlmann, "Selective Tri- and Tetramerization of Ethylene - from Ligand Design to Mini-Plant Operation", Dissertation, Erlangen 2006
- D3 WO 2007/007272 A2
- D4 R. Walsh et al., Applied Catalysis A: General, 306 (2006) 184-191

V. With its statement of grounds of appeal, the patent proprietor filed auxiliary requests 1 to 18, auxiliary request 17 corresponding to auxiliary request 16 underlying the decision under appeal.

VI. Wording of the relevant claims

Claim 1 of the main request (claims as granted) reads as follows:

"A continuous flow process for the oligomerization of ethylene, said process comprising

I) adding ethylene and solvent to a mixed reactor and contacting said ethylene under oligomerization conditions with a catalyst system comprising

1) a diphosphine ligand defined by the formula

(R1) (R2)-P1-bridge-P2(R3) (R4) wherein R1, R2, R3 and R4 are independently selected from the group consisting of hydrocarbyl and heterohydrocarbyl and the bridge is a moiety that is bonded to both phosphorus atoms;

2) a source of Cr; and

3) an activator

II) removing a product discharge stream comprising hexene, octene, C10+ oligomers and solvent from said reactor; and

III) controlling the flow of said solvent to said reactor such that the product discharge stream contains from 2 to 25 weight % octene, based on the weight of hexene, octene, C10+ oligomers and solvent; and wherein said process is further characterized by being conducted at a catalyst concentration of from 0.3 to 5 micromolar Cr."

Claim 11 as granted reads as follows:

"The process of claim 1 wherein step III) also comprises controlling the flow of ethylene to said

reactor such that the product discharge stream contains from 2 to 25 weight % octene."

Claim 1 of auxiliary requests 1 to 9 is identical to claim 1 as granted.

Claim 1 of auxiliary requests 10 and 13 contains the following additional limitation ("amendment A") over claim 1 as granted:

"[;] wherein the concentration of ethylene in said mixed reactor is from 5 to 20 weight %".

Claim 1 of auxiliary requests 11 and 14 to 17 corresponds to claim 1 as granted, save for the following alternative additional limitation ("amendment B"):

"[;] wherein the ethylene and solvent are added to a single continuously stirred tank reactor".

Claim 1 of auxiliary requests 12 and 18 is based on claim 1 as granted but comprises the following additional limitation ("amendment C"):

"wherein the process is conducted at a temperature of from 35 to 45 °C, an ethylene concentration of from 5 to 20 weight% and wherein said solvent is selected from the group consisting of cyclohexane and heptane".

VII. The patent proprietor's arguments, where relevant to the present decision, can be summarised as follows:

- (a) The subject-matter of claim 11 as granted did not extend beyond the content of the application as filed. In particular, there was clear and unambiguous disclosure in the application as filed for controlling ethylene flow rates to influence the concentration of octene. It disclosed that

ethylene was dissolved in a solvent. Controlling the flow of said solvent to the reactor such that the product discharge stream contained from 2 to 25 weight % octene thus also meant controlling the flow of ethylene for the same purpose. Controlling the flow rate of ethylene to reach preferred levels of ethylene was also derivable from the application as filed. It could also be inferred from other passages that controlling the ethylene flow rate could be used to influence the concentration of octene. There was thus a clear connection between action and purpose.

- (b) The subject-matter of claim 1 as granted involved an inventive step over both D1 and D3 as the closest prior-art documents.

The subject-matter of claim 1 as granted differed from the disclosure of D1 on account of the following features:

- (i) Figure 23 of D1 did not disclose a mixed reactor but a stirred-tank saturator and a plug flow tubular reactor (PFTR) for the oligomerisation of ethylene;
- (ii) D1 did not teach actively controlling the octene concentration by way of the solvent flow rate;
- (iii) the chromium catalyst concentration was not within the range claimed at all times during the process.

As regards the subject-matter of claim 1 of auxiliary request 14, including the aforementioned "amendment B", there was no embodied disclosure in D1 of a single continuously stirred tank reactor (CSTR) either. Hence, this amendment established a

fourth distinguishing feature over D1 for this request. D1 taught against replacing PFTRs with CSTRs in the oligomerisation of ethylene, and a skilled person would not have transferred the chromium catalyst concentration ranges used in D1 for PFTRs to processes using mixed reactors. Doing so would have resulted in entirely new processes that required the adaptation of the process parameters. Hence, the subject-matter of claim 1 was not obvious in view of D1 and thus met the requirement of Article 56 EPC.

In view of Example 29 of D3 as the alternative starting point for the assessment of inventive step, an octene concentration of between 2 to 25 weight % in the product discharge stream and the control of the solvent flow established two distinguishing features over claim 1 as granted. Page 3, lines 1 to 5 of D3 did not disclose an active solvent flow control in order to adjust the octene concentration. Instead, this measure aimed to lower/adjust the aluminium and chromium concentrations and dilute the catalyst system. The technical effect associated with the distinguishing features was that of reducing the C10+ content (compounds with ten or more carbon atoms) in the product. The objective technical problem was to provide a continuous flow process for the oligomerisation of ethylene that achieved a reduction in the level of C10+ in the product stream. The solution, namely to control the solvent flow to maintain the octene level at 2 to 25 weight %, was not obvious. *Inter alia*, the aforementioned passage on page 3 of D3 was not compatible with Example 29 as the ratio of ethylene to octene product in the second reactor was not increased,

but decreased. What was more, D3 taught an increase in the octene level in the product as much as possible instead of adjusting the octene level in the product stream to levels from 2 to 25 weight %. The missing link was not derivable from D1 or D4 either.

The additional limitation resulting from "Amendment A" in claim 1 of auxiliary request 10 led to improved octene selectivity and was not obvious.

The restriction of the temperature range to 35 to 45°C in claim 1 of auxiliary request 18 improved selectivity especially in combination with the claimed ethylene concentration range of 5 to 20 weight %. Furthermore, a different solvent from that claimed was used in Example 29 of D3. The subject-matter of claim 1 was thus not obvious.

VIII. The opponent's arguments, where relevant to the present decision, can be summarised as follows:

- (a) The subject-matter of claim 11 as granted extended beyond the content of the application as filed. The application did not disclose controlling the flow of ethylene for the purpose of maintaining the level of octene in the product stream at levels from 2 to 25 weight %.
- (b) Starting from Figure 23 of D1 as the closest prior art, the distinguishing feature was the use of a mixed reactor in claim 1 as granted. No advantage was associated with this difference. Accordingly, the objective technical problem was to provide an alternative process for the oligomerisation of ethene. D1, however, taught that a CSTR was a

realistic alternative to the PFTR. D1 also taught that low chromium concentrations were beneficial in terms of catalyst activity and selectivity as regards the combined hexene and octene content in the product. Finally, D1 also disclosed that a high product concentration (1-hexene and 1-octene) in the reaction mixture fostered the secondary incorporation of the product into the catalytic cycle and hence C10+ oligomer formation. A high octene concentration in the reaction stream was thus obviously not desirable. This merely reflected chemical common sense. There was thus no reason why the skilled person would not have used an octene concentration of 2.9 weight % (resulting from Figures 62 and 66) when adapting the teaching in D1 relating to PFTRs to processes involving CSTRs instead. The subject-matter of claim 1 as granted was thus obvious in view of D1.

This conclusion applied equally to the subject-matter of claim 1 of auxiliary request 14 (comprising, as an additional limitation, the aforementioned "Amendment B") and of claim 1 of auxiliary request 18 (instead including "Amendment C").

Neither the main request nor any of the auxiliary requests involved an inventive step in view of document D3 as the closest prior art even if the feature relating to the octene concentration were considered not to be disclosed in this document.

IX. Final requests

The patent proprietor requested that the decision under appeal be set aside and that the patent be maintained

on the basis of the main request (patent as granted) or alternatively on the basis of one of auxiliary requests 1 to 18, filed with the statement setting out the grounds of appeal.

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

Reasons for the Decision

1. Amendments (Article 100(c) EPC) - main request

1.1 The board concurs with the opposition division's assessment that the subject-matter of claim 11 as granted adds subject-matter not disclosed in the original application documents. In the application, there is no direct and unambiguous disclosure of controlling the ethylene flow to obtain a product discharge stream comprising from 2 to 25 weight % octene. This purpose is not reflected on pages 9 (lines 32 to 33), 15 (lines 9 to 10) and 22 (lines 32 to 34) of the description as filed. Page 9, lines 32 to 33 mentions preferred levels of ethylene (in the reactor), and the aforementioned passage on page 15 discloses the variation of, *inter alia*, the ethylene flow rates. By contrast, the passage on page 22, lines 29 to 34 makes it clear that the "ethylene concentration" is controlled/influenced by the rate of solvent addition and the reaction rate. The passage on page 13, lines 31 to 33, cited by the patent proprietor in the oral proceedings, merely states that ethylene is dissolved in solvent prior to being added to the reactor. It does not disclose that this ethylene flow is controlled with the purpose of obtaining a specific octene concentration (from 2 to 25 weight %) in the solvent-

containing discharge stream, rather than of controlling/influencing the ethylene concentration by the rate of solvent addition and the reaction rates, as taught on page 22, lines 29 to 34. The fact that the ethylene concentration in the reactor also influences the fraction of octene in the (oligomer) product obtained does not alter this conclusion. Therefore, the subject-matter of claim 11 extends beyond the content of the application as filed, and the ground for opposition under Article 100(c) EPC (cf. Article 123(2) EPC) prejudices the maintenance of the patent as granted.

2. *Inventive step (Article 100(a) EPC and Article 56 EPC)*
- main request

2.1 The patent

The patent is directed to a continuous process for the oligomerisation (in particular tetramerisation) of ethylene in the presence of a chromium catalyst having a bridged diphosphine ligand. The oligomerisation reaction is conducted in a mixed reactor containing a solvent.

2.2 Closest prior art

In the decision under appeal, the assessment of inventive step of the subject-matter of claim 1 as granted (when assessing inventive step of what was then auxiliary request 2A) is based, *inter alia*, on document D3 (in particular Example 29) as the closest prior art. Document D3 is also directed to the oligomerisation of ethylene in the presence of chromium catalysts in suitable solvents. Document D3 is thus a suitable starting point for assessing inventive step.

The opposition division's decision is based on Example 29 of document D3 as the starting point in the problem-solution approach. The board sees no reason to deviate from this.

2.3 Distinguishing feature

Whether or not Example 29 of D3 implicitly disclosed an octene concentration in the discharge stream from 2 to 25 weight % was a contentious issue between the parties. The question of whether this feature is disclosed in D3 can, however, be left unanswered because even if this feature is considered to be a distinguishing feature, the claimed subject-matter is not allowable for lack of inventive step, as set out below.

The board endorses the opposition division's conclusion that the act of controlling the solvent flow to the reactor cannot be regarded as a further distinguishing feature. It follows from page 3, lines 1 to 5 of D3 that the solvent flow is purposively controlled, causing a reduction in the formation of olefins with ten or more carbon atoms (C10+ fraction). Deliberate control of the solvent flow rate also takes place in Example 29 of D3; see lines 12 to 16 on page 42 and lines 20 ff. on page 46. By adjusting the solvent flow rate, the catalyst is purposively diluted to reduce the formation of C10+ products. In view of the product composition displayed in Table 1, the resulting C10+ fraction amounts to at most 14.5 weight % and is thus comparable to the results featured in Table 2 of the patent. Hence, the opponent's line of argument that D3 also discloses controlling the solvent flow is convincing.

Whether or not the passage on page 3, lines 1 to 5, on which the patent proprietor relied, is compatible with the disclosure of Example 29 of D3 thus does not need to be discussed.

2.4 Technical effect and objective technical problem

No particular effect has been demonstrated to be associated with the range for the octene content in the discharge stream called for in claim 1; the board agrees with the opponent that Figure 1 shows the entirety of the product (hexene and octene) formed in the reactor rather than only the octene concentration present in the reactor. Hence, Figure 1 of the patent supports the conclusion that the amount of C10+ in the discharge stream increases as the amount of *product* (and not only the amount of the *octene* contained in the stream, but also the amount of the hexene) in the discharge stream increases (see e.g. paragraphs [0075], [0080] and [0083] of the patent, to which the parties referred, *inter alia*). Similarly, the graphical representation of the data provided in Table 2 of the patent on page 2 of the reply to the patent proprietor's statement of grounds of appeal does not show a correlation between the C10+ selectivity and the octene concentration in the final product. Hence, the opponent's argument that the control of the hexene concentration in the product stream would also be necessary to control the amount of C10+ oligomers formed is valid.

Consequently, the objective technical problem is to provide an *alternative* process for the oligomerisation of ethene.

2.5 Obviousness

- 2.5.1 The board agrees with the opponent that the skilled person studying document D3 would have been aware of the fact that the concentration of octene in the discharge stream can be controlled, *inter alia*, by adjusting the solvent flow rate. Reducing the concentration of octene in the reactor by increasing the solvent flow rate removes the starting compound/octene for the formation of higher oligomers by secondary incorporation (cf. also page 3, lines 1 to 5 of D3, which also mentions the formation of secondary products from the primary reaction products). Hence, the concentration of octene in the product stream formed can, *inter alia*, be controlled/adjusted (to values such as from 2 to 25 weight %) by the residence time and concentration (adjusted by the solvent flow rate) of the reactants in the reactor in an obvious way.
- 2.5.2 This competitive reaction of 1-hexene and 1-octene with ethene is also featured in D4 (see Scheme 4 and second paragraph of the left-hand column on page 190). Furthermore, it is not apparent to the board that the recommendation on page 190 of D4 of minimising the concentration of the primary olefin reaction products to avoid secondary reactions would only apply to batch-type oligomerisations of ethylene, as argued by the patent proprietor.
- 2.5.3 What is more, in D3, product oligomers are already formed during catalyst activation. It is thus also apparent from this fact that the octene content in the reactor (and thus in the discharge stream) can be adjusted by the solvent flow rate in an obvious way.

- 2.5.4 The patent proprietor's argument that D3 taught the maximisation of the octene content in the product is not persuasive; the passage on page 9 entitled "Oligomeric product" does not necessarily hint at octene contents of at least 35 weight % in the product formed. By contrast, the olefinic product can also be a mixture of hexene and octene, and said passage features the composition of the *product* rather than that of the *discharge stream* and its composition.
- 2.5.5 Likewise, the use of an inert liquid medium/solvent is preferred in D3 rather than using the olefinic product, such as octene, as the liquid medium (see page 21, lines 4 to 12).
- 2.5.6 The skilled person would thus have adjusted the octene concentration in order to produce a mere alternative to the explicitly mentioned oligomerisation process. Therefore, the subject-matter of claim 1 is obvious to a skilled person in view of D3 and common general knowledge or in view of D3 taken in combination with the teaching of D4 as a secondary source of information.
- 2.5.7 Consequently, the ground for opposition pursuant to Article 100(a) in combination with Article 56 EPC prejudices the maintenance of the patent as granted.

3. *First to ninth auxiliary requests - inventive step*

Concerning inventive step, the objections raised against claim 1 as granted apply equally to claim 1 of the first to ninth auxiliary requests. Those requests thus do not meet the requirement of Article 56 EPC.

4. *Auxiliary requests 10 and 13 - inventive step
(Article 56 EPC)*

4.1 Closest prior art and distinguishing features

Document D3 served as the closest prior art for assessing inventive step of the subject-matter of claim 1 in the decision under appeal in the context of auxiliary request 13. Claim 1 of auxiliary requests 10 and 13 on file is identical to this claim and differs from claim 1 as granted on account of the aforementioned inserted "Amendment A". Likewise, document D3, and in particular Example 29, was the starting point for the analysis of inventive step in the appeal proceedings.

An ethylene pressure of 45 bar is set in Example 29 of D3, but the corresponding ethylene concentration in the solution is not mentioned. Hence, the feature "wherein the concentration of ethylene in said mixed reactor is from 5 to 20 weight %" is considered to constitute a (second) distinguishing feature.

4.2 Technical effect and objective technical problem

4.2.1 By referring to the explanations provided in paragraph [0100] of the patent, the patent proprietor argued that, within the claimed range for the ethylene concentration from 5 to 20 weight %, an improved octene selectivity was obtained. This effect also constituted the resulting objective technical problem to be solved in view of document D3 as the closest prior art.

4.2.2 The board, however, endorses the opposition division's conclusion that the additional limitation, introduced into claim 1 as granted and referred to as "Amendment

A", does not confer inventive step for the following reasons.

- 4.2.3 No effect that would be causally ascribable to this feature has been corroborated, and no comparative examples in relation to Example 29 of D3 are on file. Example 29 shows the preparation of a reaction mixture comprising a C10+ fraction making up at most 14.5 weight % of the total product, prepared at a chromium catalyst concentration of 4.5 micromoles per litre. The product obtained comprises 69.2 weight % of 1-octene, thus exceeding the octene content of most of the samples featured in Table 2 of the patent.
- 4.2.4 The opponent also referred to run 30 in Table 2 of the patent to substantiate that the range for the ethylene concentration called for in claim 1 was arbitrary. In run 30, despite exceeding the claimed range for the ethylene concentration, the octene content in the product is high (71.3 weight %). As regards the lower threshold of the range, a comparison between runs 4 and 11 does not reflect a greater selectivity for octene when comparing an ethylene concentration of 7.93 weight % in run 4 with 4.55 weight % obtained in run 11, either.
- 4.2.5 Therefore, the board concludes that the data shown in Table 2, such as those for run 30, do not prove the alleged criticality of the aforementioned range.
- 4.2.6 In view of these considerations and the lack of a demonstrated criticality of the range for the ethylene content called for in claim 1, the objective technical problem to be solved is still to provide an alternative process for the oligomerisation of ethylene.

4.3 Obviousness

4.3.1 Adjusting the ethylene concentration in the mixed reactor, such as in Example 29 of D3, to values ranging from 5 to 20 weight % does not require inventive skill. Such an adjustment of the ethylene concentration could obviously have been implemented e.g. by setting suitable reaction rates, ethylene pressure and/or solvent flow rates. Consequently, the board does not agree with the patent proprietor's argument that the skilled person was not imaginary and thus would not adjust the ethylene concentration. Merely faced with the problem of providing an alternative, the skilled person would be prompted to modify this process parameter.

4.3.2 Hence, the subject-matter of claim 1 of auxiliary request 10 is obvious to a skilled person in view of D3 and thus does not meet the requirement of Article 56 EPC.

4.4 These considerations apply equally to claim 1 of auxiliary request 13, which thus does not meet the requirement of Article 56 EPC either.

5. *Eleventh and twelfth auxiliary requests - amendments*

The objections raised against claim 11 as granted apply equally to the corresponding claim (claim 10) of the eleventh and twelfth auxiliary requests. Those requests thus do not meet the requirement of Article 123(2) EPC.

6. *Auxiliary request 14 - inventive step*

6.1 Closest prior art

In the oral proceedings before the board, the assessment of inventive step was based on document D1, and in particular Figure 23 of this document, as a starting point.

6.2 Distinguishing features

6.2.1 Claim 1 differs from claim 1 as granted on account of the feature "[;] wherein the ethylene and solvent are added to a single continuously stirred tank reactor", i.e. the aforementioned "Amendment B". The patent proprietor established the following four features that distinguished the subject-matter of claim 1 from the disclosure of D1:

- (a) the use of a mixed reactor instead of a PFTR and a stirred saturator;
- (b) the step of "controlling the flow of said solvent to said reactor such that the product discharge stream contains from 2 to 25 weight % octene", which required active control of the solvent flow rate;
- (c) a concentration of the catalyst in the reactor within the range of 0.3 to 5 $\mu\text{mol/l}$ of chromium at all times during the process;
- (d) the use of a *single* CSTR.

6.2.2 By contrast, the board takes the view that with regard to the experiments conducted in D1 in a PFTR as shown in Figure 23, the distinguishing features are the above features (c) and (d) only.

Acknowledging the use of a single CSTR as a

distinguishing feature also implies the use of a mixed reactor, i.e. the above feature (a). As pointed out by the opponent, D1 discloses the active control of the solvent flow rate and its impact on the reaction conditions in the reactor; see entries 4 to 6 in Table 20 on page 127. Furthermore, such "actively" controlled solvent flow rates are described in D1 in the context of product concentration values of up to 50 g/l, translating into octene concentrations as called for in claim 1 in view of the data provided in Figures 62 and 66 and corresponding calculations provided by the opponent. Therefore, feature (b) is also disclosed in D1.

6.3 Technical effect and objective technical problem

No examples are on file that would compare the PFTR oligomerisation reactions in D1 with processes in accordance with claim 1. Nevertheless, comparing the product selectivity values accomplished in D1 with those in Table 2 of the patent, no improvement that could be ascribable to the distinguishing features can be established. By contrast, Table 2 of the patent demonstrates in parts markedly inferior results in terms of selectivity (hexene and octene) and corresponding C10+ levels for embodiments falling within the scope of claim 1. Hence, the resulting objective technical problem is to provide *alternative* processes for the oligomerisation of ethene.

6.4 Obviousness

6.4.1 With regard to feature (c) as set out in section 6.2.1, the patent proprietor stressed that the skilled person would not transfer the specific chromium concentration range reported in D1 for PFTR-based ethylene

oligomerisation reactions to mixed reactors. Page 128 of D1 disclosed an initial chromium concentration of 12.5 $\mu\text{mol/l}$ in the process that was successively decreased stepwise, as was also apparent from Figure 61. All impurities were removed by the higher initial chromium concentration. D1 thus taught against keeping the chromium concentration in the reactor at levels as required in claim 1 throughout the entire process; however, this difference brought about higher catalyst activity and allowed for all the other benefits associated with the process in claim 1. As a result, the solution provided by the subject-matter of claim 1 was not inferior to that provided by a PFTR in D1.

6.4.2 This argument is not convincing. As correctly pointed out by the opponent, D1 recommends low chromium concentrations of 2.5 $\mu\text{mol/l}$ (see last paragraph on page 149). D1 does not propose starting the ethylene oligomerisation at high chromium concentrations. Instead, as argued by the opponent, it follows from the explanations given on page 93 that, at very low chromium concentrations of 0.78 or about 1.6 $\mu\text{mol/l}$, the chromium catalyst is poisoned by contaminants present in the system and is extremely sensitive to impurities. Whilst D1 hints at avoiding very low catalyst concentrations (leaving low levels of active catalyst), it cannot be inferred from the teaching of the last paragraph on page 128 that an initial chromium concentration of 12.5 $\mu\text{mol/l}$ would be essential for removing initial impurities. D1 thus does not teach against a constant chromium concentration of 2.5 $\mu\text{mol/l}$, but, in the PFTR experiments, explores the effect of varying reaction conditions stepwise (such as the chromium concentration; see e.g. Figure 61). Chromium concentrations of 2.5 and 5 $\mu\text{mol/l}$, tested in D1 for ethylene oligomerisations in both stirred reactors

(semi-batch mode) and PFTRs (continuous mode), resulted in high catalyst activities. The significant improvement in catalyst activity went hand in hand with a very high constant alpha selectivity in terms of combined 1-hexene and 1-octene concentrations in the product above 90 weight % (see first two paragraphs on page 134 of D1 and Figure 62). D1 thus teaches chromium catalyst concentrations as stipulated in claim 1. The board sees no reason why a skilled person would not, with a reasonable expectation of success, start from the lowest chromium concentration of 2.5 $\mu\text{mol/l}$, yielding high catalyst activity and alpha selectivity in terms of obtained 1-hexene and 1-octene levels in the product above 90 weight % in D1 in a PFTR, when contemplating moving from such a PFTR to a CSTR.

6.4.3 In respect of feature (d), the patent proprietor argued that D1 would teach against moving from a PFTR to a single CSTR. The teaching on page 45 of D1 made it clear that a higher degree of secondary incorporation of product into the catalytic cycle had to be expected for CSTRs in comparison with PFTRs, resulting in higher C10+ levels at the expense of hexene and octene.

6.4.4 In view of the problem to be solved being an alternative process, i.e. the least ambitious problem, this argument is not convincing. D1 discusses in detail the advantages and disadvantages of CSTRs compared with PFTRs. In the light of the disclosure of D1, the decreased selectivity in terms of combined hexene and octene weight fraction in the product (about 80 weight % to less than 90 weight % in Table 2 of the patent vs. greater than 90 weight % in D1) was foreseeable. Table 19 on page 125 of D1, for instance, mentions this disadvantage by referring to "lower selectivity". The route taken in D1 using the PFTR concept (associated

with the *advantage of low average product concentration*) was taken in order to *maximise* the yield of 1-octene and 1-hexene (see first paragraph on page 125, to which the opponent referred in its grounds of appeal).

D1 also mentions that PFTR and CSTR are "natural options" and the most prominent ones for a continuous ethylene tetramerisation/oligomerisation process (see first paragraphs on pages 44 and 125 of D1). Hence, whilst a chromium catalyst present in a CSTR reactor will always operate at a relatively high concentration level of products, thus facilitating secondary incorporation of product in the catalytic cycle, in the view of the board there is no prejudice in D1 against using CSTRs. As mentioned, however, the corresponding effect of a lower selectivity for hexene and octene due to secondary incorporation of these products in the catalytic cycle is already described in D1, is not surprising and is confirmed by the results set out in Table 2 of the patent.

In view of these considerations, when merely wishing to provide an alternative process the skilled person would have contemplated employing a CSTR reactor instead of a PFTR with a reasonable expectation of success when faced with the given problem.

6.4.5 When moving from a PFTR process to a CSTR process, the skilled person would have transferred over a solvent flow, octene and a chromium concentration as employed for the continuous PFTR process as a starting point. It has not been substantiated that these parameters are incompatible with a process using a (single) CSTR, and such incompatibility is not derivable from D1, either. By contrast, D1 strongly hints at catalyst

concentrations of 2.5 $\mu\text{mol/l}$ chromium and clearly teaches that a relatively high product concentration (octene and hexene) in the reaction mixture in a CSTR facilitates secondary incorporation of product and thus the formation of C10+ oligomers. The skilled person would thus have avoided high octene concentrations in the product/reactor discharge stream. Instead, they would have started from octene concentrations disclosed in D1 in the context of the PFTR experiments. As calculated from Figures 62 and 66 of D1 by the opponent, these octene levels fall within the scope of claim 1, towards the lower end-point of the octene concentration.

- 6.4.6 Hence, a skilled person would start from the continuous PFTR process and the process conditions applied in D1 with a reasonable expectation of success in order to arrive at an alternative ethylene oligomerisation process using a (single) CSTR instead of a PFTR.

Consequently, the subject-matter of claim 1 is obvious to a skilled person in view of D1 and does not meet the requirement of Article 56 EPC.

7. *Auxiliary requests 15 to 17*

Claim 1 of auxiliary requests 15 to 17 is identical to claim 1 of auxiliary request 14. Hence, the conclusions arrived at in point 6 in respect of a lack of inventive step apply *mutatis mutandis*.

8. *Auxiliary request 18 - inventive step*

- 8.1 Inventive step was discussed in the oral proceedings starting in particular from document D3 as the closest prior art.

8.2 Claim 1 of auxiliary request 18 comprises "Amendment C", i.e. the ethylene concentration as in "Amendment A", and in addition a process temperature in the range from 35 to 45°C as well as the solvent being selected from cyclohexane and heptane. Starting from document D3, the remarks made in section 4.2 above with respect to claim 1 of auxiliary requests 10 and 13 containing "Amendment A" apply equally, with the following additional comments.

D3 also discloses *cyclohexane* as an alternative solvent to be used in the ethylene oligomerisations (page 22, line 15). In the absence of an effect that could be associated with the substitution of Isopar in Example 29 with cyclohexane as an alternative solvent, this additional feature cannot confer an inventive step either.

Finally, D3 discloses a preferred *temperature* range from 15 to 130°C on page 21, line 27. No technical effect has been substantiated that would be associated with changing the reaction temperature in Example 29 (60°C) to a value within the range claimed either, in particular for temperature values below 45°C, which are not embodied in the patent.

Consequently, the subject-matter of claim 1 is obvious to a skilled person and does not meet the requirement of Article 56 EPC.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.
2. The patent is revoked.

The Registrar:

The Chairman:



H. Jenney

A. Haderlein

Decision electronically authenticated