

REVISED VERSION

(19) World Intellectual Property  
Organization  
International Bureau



(10) International Publication Number  
**WO 2017/036794 A9**

(43) International Publication Date  
9 March 2017 (09.03.2017)

- (51) **International Patent Classification:**  
B01J 35/00 (2006.01) B01J 8/02 (2006.01)  
B01J8/00 (2006.01)
- (21) **International Application Number:**  
PCT/EP20 16/069482
- (22) **International Filing Date:**  
17 August 2016 (17.08.2016)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**  
PA 2015 005 13 28 August 2015 (28.08.2015) DK  
PA 2016 00081 9 February 2016 (09.02.2016) DK
- (71) **Applicant:** HALDOR TOPSØE A/S [DK/DK]; Haldor  
Topsøes Alle 1, 2800 Kgs. Lyngby (DK).
- (72) **Inventors:** MORTENSEN, Peter Molgaard; Tofteengen  
27, 4000 Roskilde (DK). ØSTBERG, Martin; Odinsvej 5,  
Tune, 4000 Roskilde (DK). HØJLUND NIELSEN, Poul  
Erik; Rolandsvej 3, 3480 Fredensborg (DK).

(74) **Agent:** HALDOR TOPSØE A/S; Haldor Topsøes Alle 1,  
2800 Kgs. Lyngby (DK).

(81) **Designated States** (unless otherwise indicated, for every  
kind of national protection available): AE, AG, AL, AM,  
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,  
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,  
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,  
HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR,  
KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG,  
MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM,  
PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC,  
SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN,  
TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** (unless otherwise indicated, for every  
kind of regional protection available): ARIPO (BW, GH,  
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ,  
TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU,  
TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE,  
DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU,  
LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK,  
SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ,  
GW, KM, ML, MR, NE, SN, TD, TG).

[Continued on nextpage]

(54) **Title:** INDUCTION HEATING OF ENDOTHERMIC REACTIONS

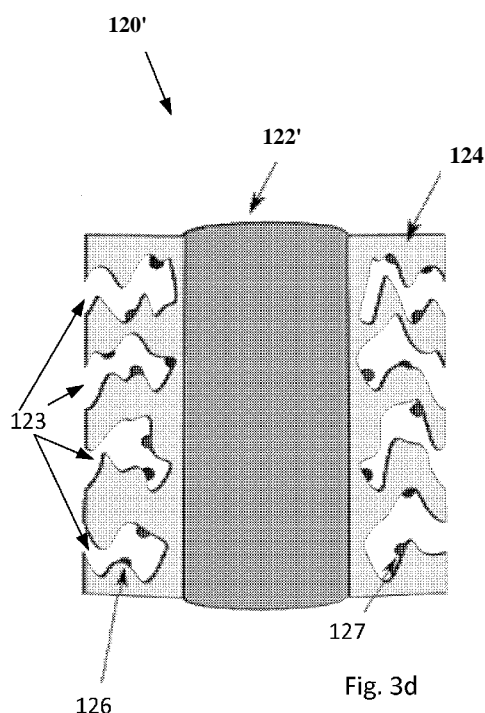


Fig. 3d

(57) **Abstract:** The invention relates to a reactor system for carrying out an endothermic catalytic chemical reaction in a given temperature range (T) upon bringing a reactant into contact with a catalyst material. The reactor system comprises a reactor unit arranged to accommodate catalyst material comprising one or more ferromagnetic macroscopic supports susceptible for induction heating where the one or more ferromagnetic macroscopic supports are ferromagnetic at temperatures up to an upper limit of the given temperature range (T). The one or more ferromagnetic macroscopic supports are coated with an oxide, and the oxide is impregnated with catalytically active particles. The reactor system moreover comprises an induction coil arranged to be powered by a power source supplying alternating current and being positioned so as to generate an alternating magnetic field within the reactor unit upon energization by the power source, whereby the catalyst material is heated to a temperature within said temperature range (T) by means of the alternating magnetic field, where the catalyst material is arranged to be heated by said alternating magnetic field by induction of a magnetic flux in the material. The invention also relates to catalyst material and a process for carrying out an endothermic catalytic chemical reaction.

**Declarations under Rule 4.17:**

- as to the identity of the inventor (Rule 4.1 7(i))
- as to applicant's entitlement to apply for and be granted a patent (Rule 4.1 7(H))
- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.1 7(Hi))
- of inventorship (Rule 4.1 7(iv))

**Published:**

- with international search report (Art. 21(3))

- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))

**(88) Date of publication of the revised international search report:**

11 May 2017

**(15) Information about Correction:**  
see Notice of 11 May 2017

## INTERNATIONAL SEARCH REPORT

REVISED VERSION

International application No

PCT/EP2016/069482

## A. CLASSIFICATION OF SUBJECT MATTER

INV. B01J35/00 B01J8/00 B01J8/02  
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B01J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	wo 2006/071527 A2 (UNIV ARKANSAS [US] ; WILKES JON GARDNER [US] ; BUZATU DAN ALEXANDER [US]) 6 July 2006 (2006-07-06)	1-5 ,7-9 , 13-17 , 19
A	page 10, lines 17-23 ; figure 1 page 11, lines 15-30 page 12, line 20 - page 13, line 17 -----	6 , 10-12 , 18
X	FR 3 003 774 A1 (INST NAT SCIENCES APPLIQ [FR] ; CENTRE NAT RECH SCIENT [FR] ; UNIV TOUL0) 3 October 2014 (2014-10-03)	1-7
Y	page 9, line 32 - page 12, line 6; figure 1 ----- -/- .	8-19



Further documents are listed in the continuation of Box C.



See patent family annex.

\* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&amp;" document member of the same patent family

Date of the actual completion of the international search

21 March 2017

Date of mailing of the international search report

28/03/2017

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040,  
Fax: (+31-70) 340-3016

Authorized officer

Cagnol i , Mi chel e

## INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2016/069482

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	THOMAS K. HOULDING ET AL: "Appl icati on of alternati ve energy forms in catalyti c reactor engi neeri ng", GREEN PROCESSING AND SYNTHESIS, vol . 1, no. 1, 1 January 2012 (2012-01-01) , XP055089039 , ISSN: 2191-9542 , DOI : 10.1515/greenps-2011-0502	1-7
Y	paragraphs [04.3] - [05 . 1] -----	8-19
X	US 4 229 234 A (KRUTENAT RICHARD C ET AL) 21 October 1980 (1980-10-21) col umn 1, line 20 - col umn 2, line 38 col umn 3, line 35 - col umn 4, line 6 col umn 5, lines 11-49 col umn 7, lines 15-23 -----	1-19
X	US 2010/056360 AI (LEE KWANGYEOL [KR] ) 4 March 2010 (2010-03-04) the whol e document -----	8-13
X, P	wo 2016/062551 AI (HALDOR TOPSØE AS [DK] ) 28 Apri l 2016 (2016-04-28)	1-5 , 7-17 , 19
A, P	the whol e document -----	6 , 18
X	US 4 115 927 A (ROSENSWEIG RONALD E) 26 September 1978 (1978-09-26) the whol e document -----	1-5 , 7

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2016/069482

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
WO	2006071527	A2	06-07-2006	NONE	
-----					
FR	3003774	AI	03-10-2014	EP	2981355 AI 10-02-2016
				FR	3003774 AI 03-10-2014
				US	2016023201 AI 28-01-2016
				WO	2014162099 AI 09-10-2014
-----					
US	4229234	A	21-10-1980	AU	537179 B2 14-06- 1984
				BE	880958 AI 30-06- 1980
				BR	7906344 A 08-07- 1980
				CA	1140779 A 08-02- 1983
				DE	2950621 AI 10-07- 1980
				FR	2445597 AI 25-07- 1980
				GB	2039949 A 20-08- 1980
				IT	1127778 B 21-05- 1986
				JP	S5591957 A 11-07- 1980
				NL	8000014 A 01-07- 1980
				US	4229234 A 21-10- 1980
				ZA	7907060 B 26-11- 1980
-----					
US	2010056360	AI	04-03-2010	NONE	
-----					
WO	2016062551	AI	28-04-2016	NONE	
-----					
US	4115927	A	26-09-1978	NONE	
-----					