Seminário: Liderança Brasileira na Cadeia Produtiva do Nióbio

05/09/2019

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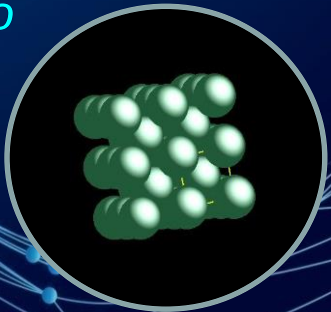
# Nióbio: aplicações em Catálise

*Dr ª Fabiana M. T. Mendes*

*Instituto Nacional de Tecnologia- Rio de Janeiro*



*fabiana.mendes@int.gov.br*

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PÁTRIA AMADA BRASIL GOVERNO FEDERAL

EMBRAPII Empresa Brasileira de Pesquisa e Inovação Industrial

# O pequeno grande mundo...

**1801** → **Início século XX-1920** (comercial/aços e ligas)

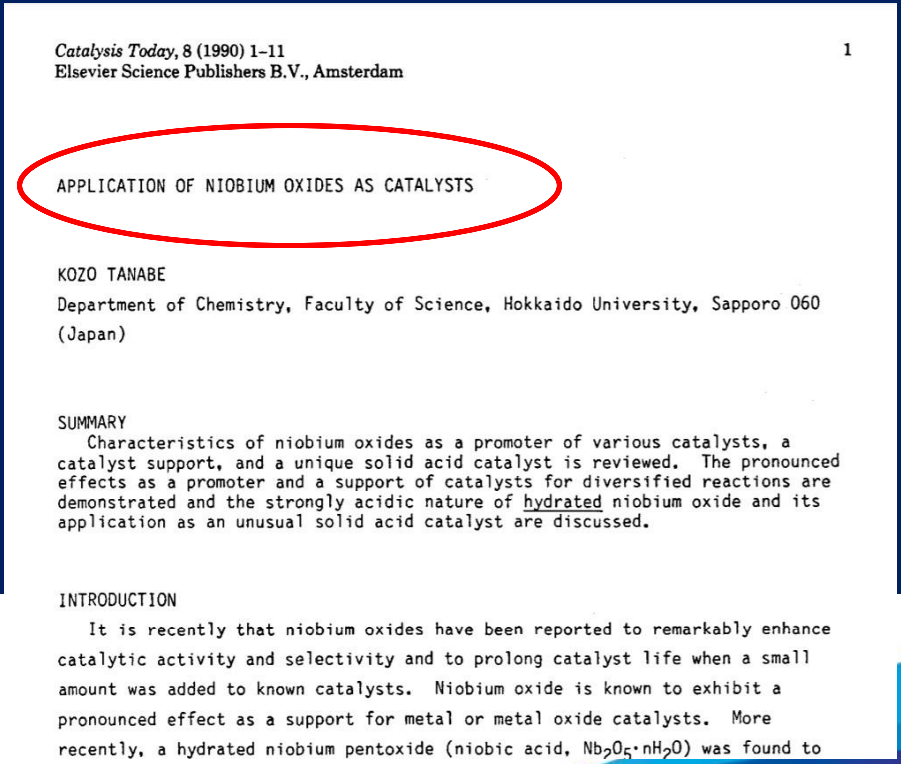
- 1980- $Nb2O5$ 99% (CBMM)
- **1989-** Akira Morikawa, Kozo Tanabe, Israel E. Wachs e Edmond I. Ko.

Catalysis Today

Supports *open access*

CATALYTIC CONVERSION WITH NIOBIUM MATERIALS Proceedings of the Niobium and Catalysts Symposium at the 1989 International Chemical Congress of Pacific Basin Societies

E.I. Ko
Volume 8, Issue 1,
Pages 1-132 (25 October 1990)



*Catalysis Today*, 8 (1990) 1–11
Elsevier Science Publishers B.V., Amsterdam

1

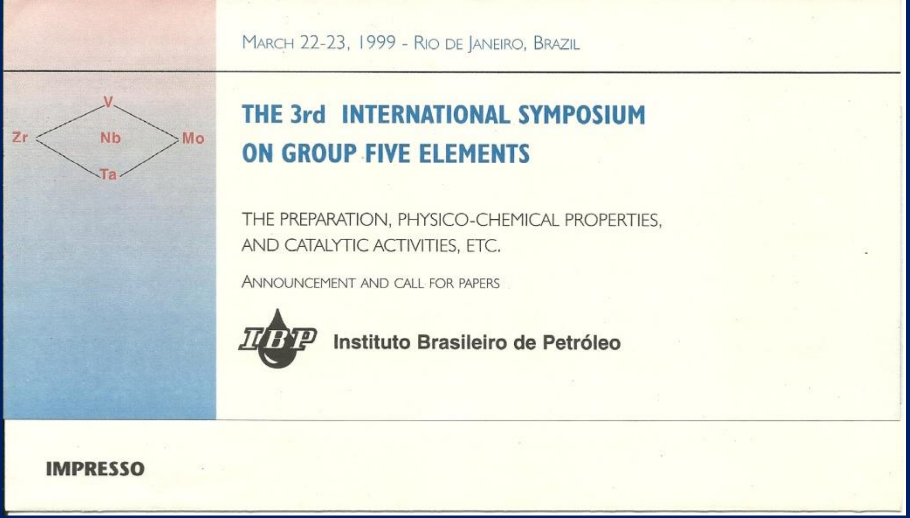
APPLICATION OF NIOBIUM OXIDES AS CATALYSTS

KOZO TANABE
Department of Chemistry, Faculty of Science, Hokkaido University, Sapporo 060 (Japan)

SUMMARY
Characteristics of niobium oxides as a promoter of various catalysts, a catalyst support, and a unique solid acid catalyst is reviewed. The pronounced effects as a promoter and a support of catalysts for diversified reactions are demonstrated and the strongly acidic nature of hydrated niobium oxide and its application as an unusual solid acid catalyst are discussed.

INTRODUCTION
It is recently that niobium oxides have been reported to remarkably enhance catalytic activity and selectivity and to prolong catalyst life when a small amount was added to known catalysts. Niobium oxide is known to exhibit a pronounced effect as a support for metal or metal oxide catalysts. More recently, a hydrated niobium pentoxide (niobic acid, $Nb_2O_5 \cdot nH_2O$) was found to

# International Symposium on Group Five Elements (1999 a ….2020)



March 22-23, 1999 - Rio de Janeiro, Brazil

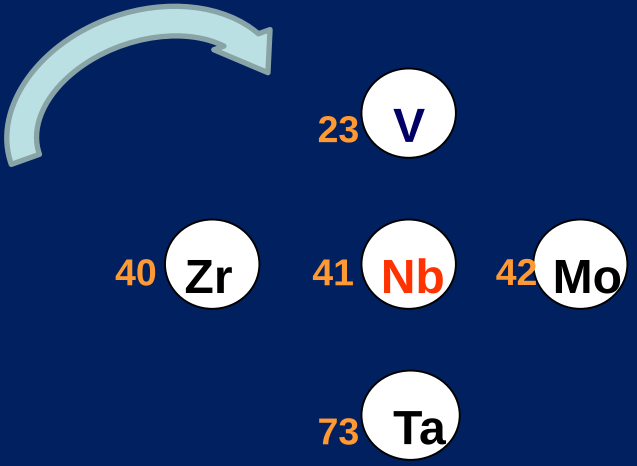
**THE 3rd INTERNATIONAL SYMPOSIUM ON GROUP FIVE ELEMENTS**

THE PREPARATION, PHYSICO-CHEMICAL PROPERTIES, AND CATALYTIC ACTIVITIES, ETC.

Announcement and call for papers

IBP Instituto Brasileiro de Petróleo

IMPRESSO



23 V

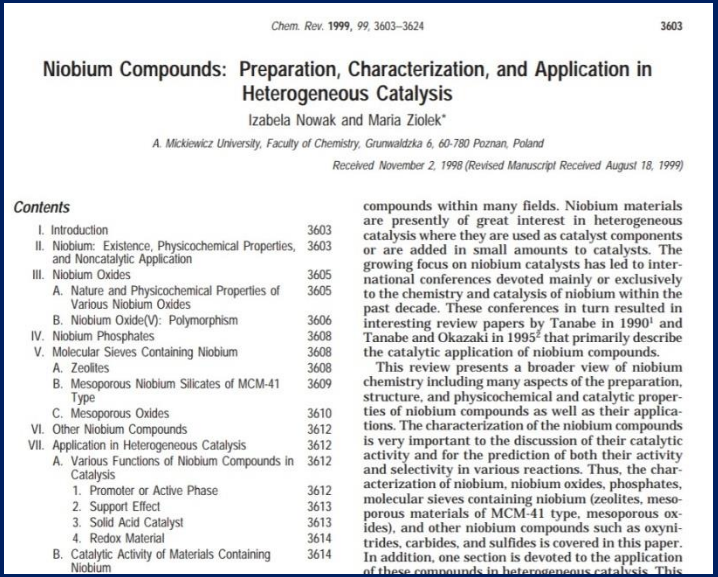
40 Zr

41 Nb

42 Mo

73 Ta

**2002- Toledo (Espanha); 2005- Hancock (USA); 2008- Poznan (Polonia); 2011-Riccione (Itália); 2014-Málaga (Espanha); 2017-Nova Delhi (India) ...**



Chem. Rev. 1999, 99, 3603–3624 3603

## Niobium Compounds: Preparation, Characterization, and Application in Heterogeneous Catalysis

Izabela Nowak and Maria Ziolek*

A. Mickiewicz University, Faculty of Chemistry, Grunwaldzka 6, 60-780 Poznan, Poland

Received November 2, 1998 (Revised Manuscript Received August 18, 1999)

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compounds within many fields. Niobium materials are presently of great interest in heterogeneous catalysis where they are used as catalyst components or are added in small amounts to catalysts. The growing focus on niobium catalysts has led to international conferences devoted mainly or exclusively to the chemistry and catalysis of niobium within the past decade. These conferences in turn resulted in interesting review papers by Tanabe in 1990[1] and Tanabe and Okazaki in 1995[2] that primarily describe the catalytic application of niobium compounds.

This review presents a broader view of niobium chemistry including many aspects of the preparation, structure, and physicochemical and catalytic properties of niobium compounds as well as their applications. The characterization of the niobium compounds is very important to the discussion of their catalytic activity and for the prediction of both their activity and selectivity in various reactions. Thus, the characterization of niobium, niobium oxides, phosphates, molecular sieves containing niobium (zeolites, mesoporous materials of MCM-41 type, mesoporous oxides), and other niobium compounds such as oxynitrides, carbides, and sulfides is covered in this paper. In addition, one section is devoted to the application

ELSEVIER

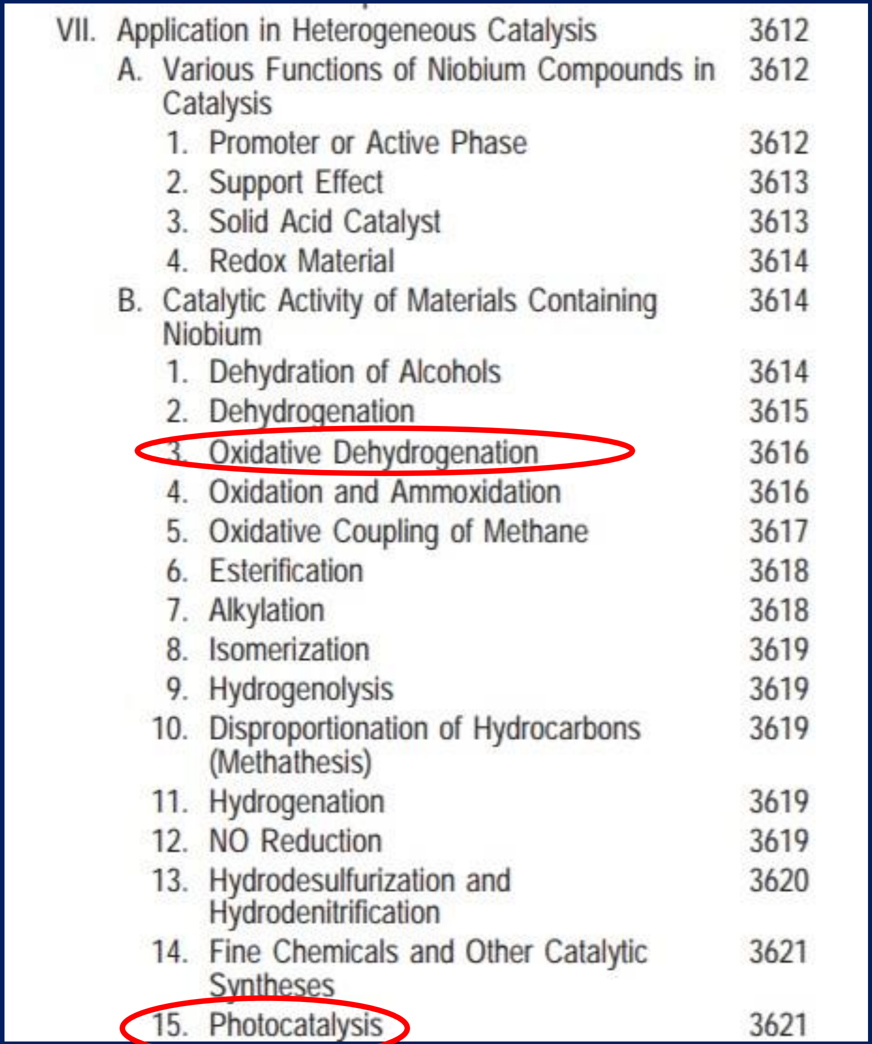
Electrochimica Acta

Volume 313, 1 August 2019, Pages 478-487

## Electrochemical investigations of $Nb_2O_5$/carbon materials from filter paper, microfibrillated and bacterial celluloses by sustainable reductive mineralization

Aurélien Henry [a], Steven Le Vot [a, d], Johan G. Alauzun [a], Peter Hesemann [a], Maria L. Foresti [b], Patricia Cerruti [b], Laurent Heux [c], Olivier Fontaine [a, d], Bruno Boury [a]

[a] Institut Charles Gerhardt de Montpellier, UMR 5253, Université de Montpellier, CNRS, ENSCM, 34095, Montpellier Cedex 5, France
[b] Instituto de Tecnología en Polímeros y Nanotecnología (ITPN), Facultad de Ingeniería, Universidad de Buenos Aires, CONICET Las Heras, 2214, CP 1127AAR Buenos Aires,



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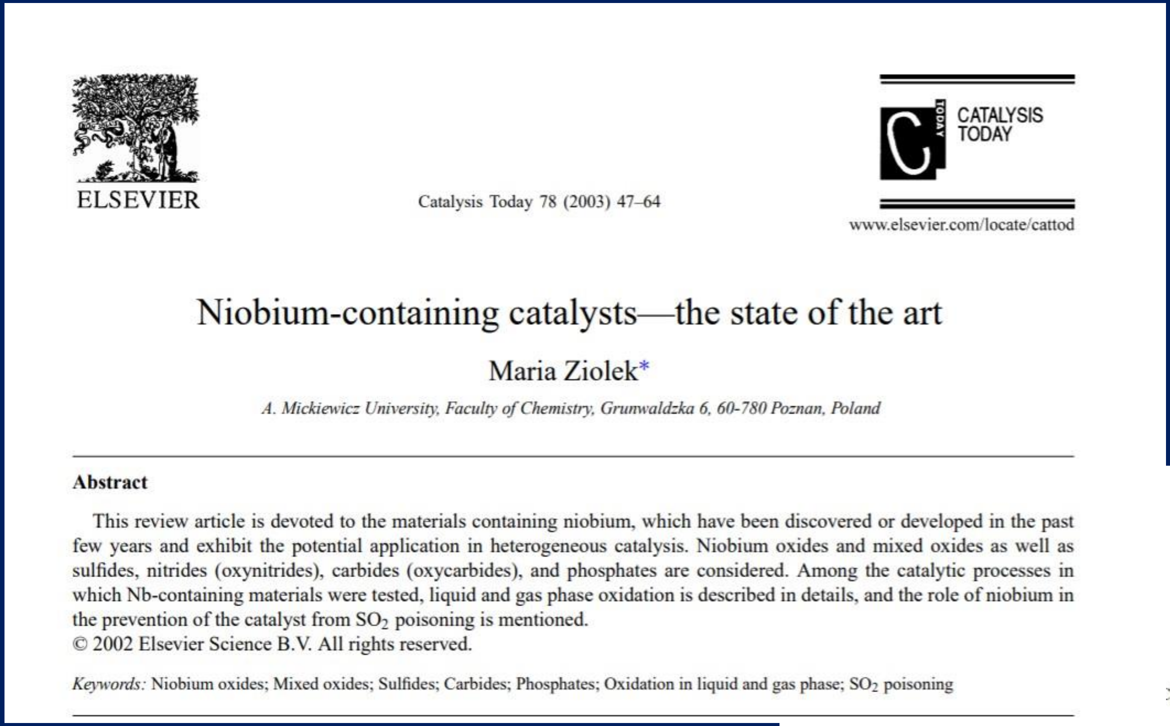
16. Eletrocatálise



ELSEVIER

Catalysis Today 78 (2003) 47–64

CATALYSIS TODAY

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# Niobium-containing catalysts—the state of the art

Maria Ziolek*

*A. Mickiewicz University, Faculty of Chemistry, Grunwaldzka 6, 60-780 Poznan, Poland*

## Abstract

This review article is devoted to the materials containing niobium, which have been discovered or developed in the past few years and exhibit the potential application in heterogeneous catalysis. Niobium oxides and mixed oxides as well as sulfides, nitrides (oxynitrides), carbides (oxycarbides), and phosphates are considered. Among the catalytic processes in which Nb-containing materials were tested, liquid and gas phase oxidation is described in details, and the role of niobium in the prevention of the catalyst from $SO_2$ poisoning is mentioned.

*Keywords:* Niobium oxides; Mixed oxides; Sulfides; Carbides; Phosphates; Oxidation in liquid and gas phase; $SO_2$ poisoning

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CATALYSIS TODAY

atalysis Today 78 (2003) 65–77

www.elsevier.com/locate/cattod

# Catalytic application of niobium compounds

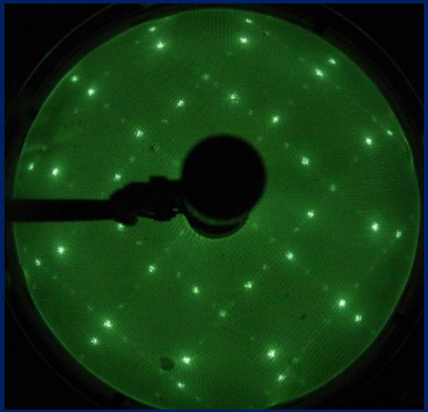
Kozo Tanabe

*14-11 Sonomachi, Oasa, Ebetsu-shi, Hokkaido 069-0851, Japan*

## Abstract

Salient examples of catalytic application of niobium compounds and materials are demonstrated. Niobium oxides, when small amounts are added to known catalysts, markedly enhance catalytic activity and selectivity and prolong catalyst life for various reactions. Moreover, niobium oxides exhibit a pronounced effect as supports of metal or metal oxide catalysts. Hydrated niobium pentoxide (niobic acid, $Nb_2O_5 \cdot nH_2O$) and niobium phosphate which are unusual solid acids show high catalytic activity, selectivity, and stability for acid-catalyzed reactions. Layer compounds containing niobium combined with metal show peculiar photocatalytic activity. These characteristic features of niobium compounds as catalysts and catalyst components are discussed, their potential significance being emphasized.

*Keywords:* Niobium compounds; Catalytic application



Catalysis Today
Volume 101, Issue 1, 15 March 2005, Pages 45-50

## TPSR of CO hydrogenation on $Co/Nb_2O_5/Al_2O_3$ catalysts

F.M.T. Mendes [a, 1], C.A.C. Perez [a], F.B. Noronha [b], M. Schmal [a]

⊞ Show more

https://doi.org/10.1016/j.cattod.2004.12.009

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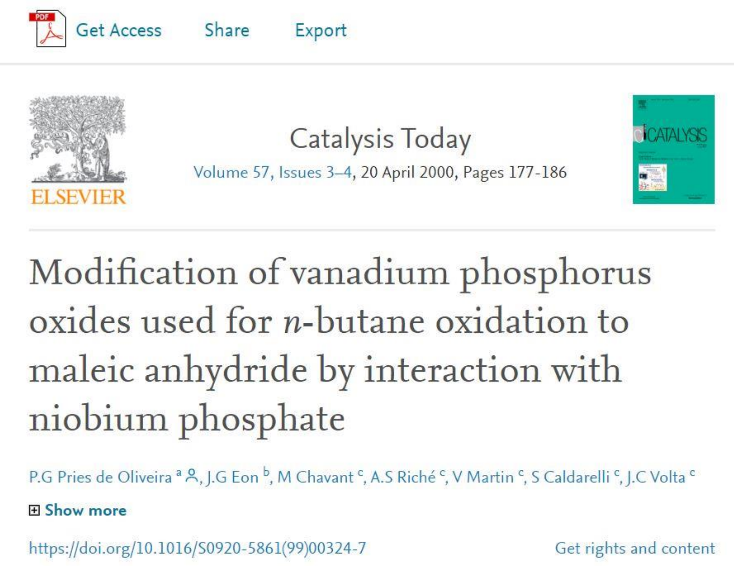

Catalysis Today
Volume 57, Issues 3–4, 20 April 2000, Pages 177-186

## Modification of vanadium phosphorus oxides used for *n*-butane oxidation to maleic anhydride by interaction with niobium phosphate

P.G Pries de Oliveira [a], J.G Eon [b], M Chavant [c], A.S Riché [c], V Martin [c], S Caldarelli [c], J.C Volta [c]

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https://doi.org/10.1016/S0920-5861(99)00324-7

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Catalysis Letters
October 2006, Volume 111, Issue 1–2, pp 35–41 | Cite as

## Strong metal support interaction on Co/niobia model catalysts

F. M. T. Mendes, A. Uhl, D. E. Starr, S. Guimond, M. Schmal, H. Kuhlenbeck, S. K. Shaikhutdinov, H.-J. Freund

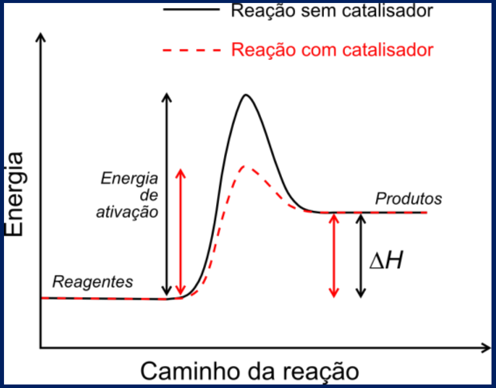
Cobalt was deposited by physical vapor deposition onto thin well-ordered niobia films in orde
to model niobia supported Co catalysts. Adsorption of CO on the Co/niobia surfaces was studied by temperature programmed desorption and infrared reflection absorption spectroscopy. Structural characterization was performed by photoelectron spectroscopy and scanning tunneling microscopy. Cobalt was found to wet the niobia film and be partially oxidized at 300 K in contrast to Co deposited on thin alumina films, where three-dimensional
metal particles are stable up to 600 K. The combined results clearly indicate a strong interaction of Co with the niobia surface including Co migration into the film, which may hav
implications for the effects of niobia observed in real catalysts.

Keywords

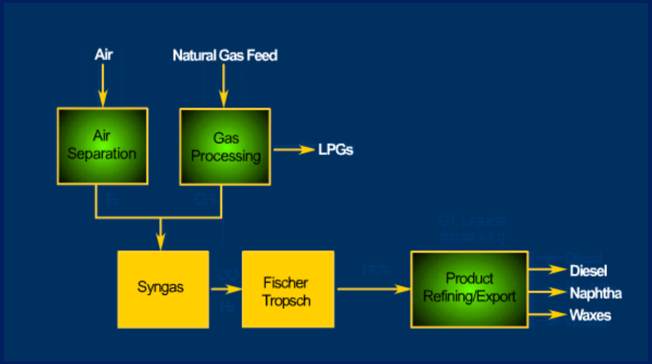
niobia cobalt CO adsorption strong metal support interaction

# Compostos de Nb aplicados na catálise

- Nióbio
  - carbetos
  - sulfetos
  - **Óxidos**
    - Nióbia mássica (“Bulk niobia)- como fase ativa
    - Nióbia- como suporte
    - Óxidos mistos
    - Nióbia suportada em vários óxidos
    - Espécies de Nb como promotoras
    - Peneiras moleculares com Nb
    - Nanopartículas de Nb suportadas
  - Nitretros/Oxi
  - Phosphatos

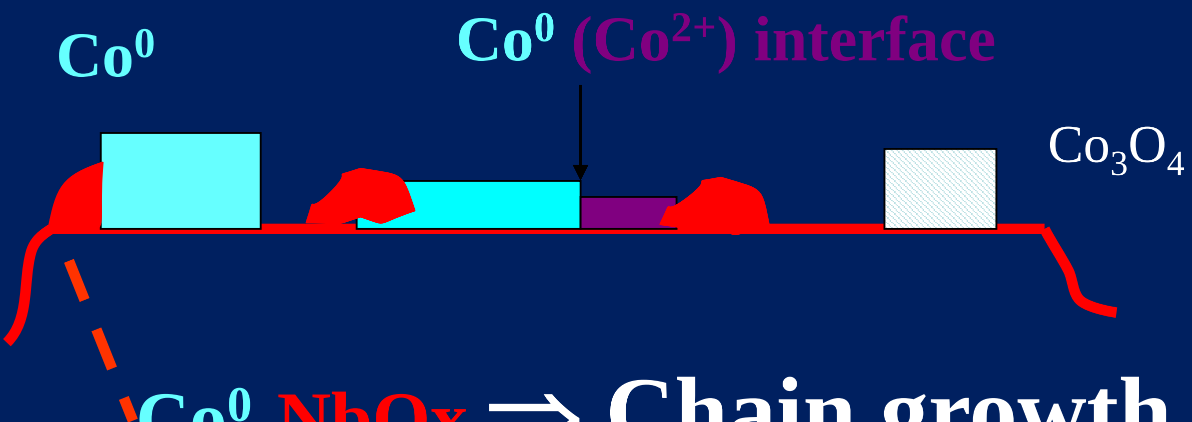


# Propriedades



## $Co/Nb_2O_5$

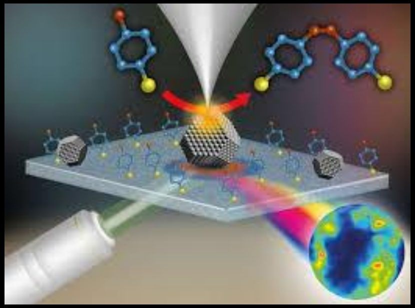
## Como é a superfície?

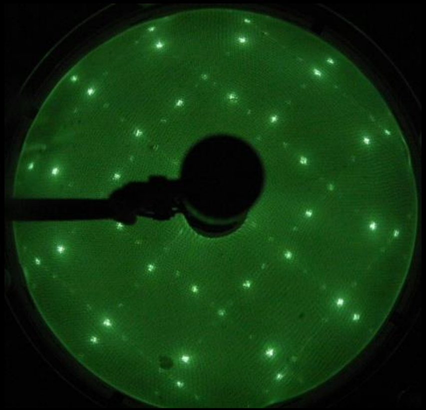


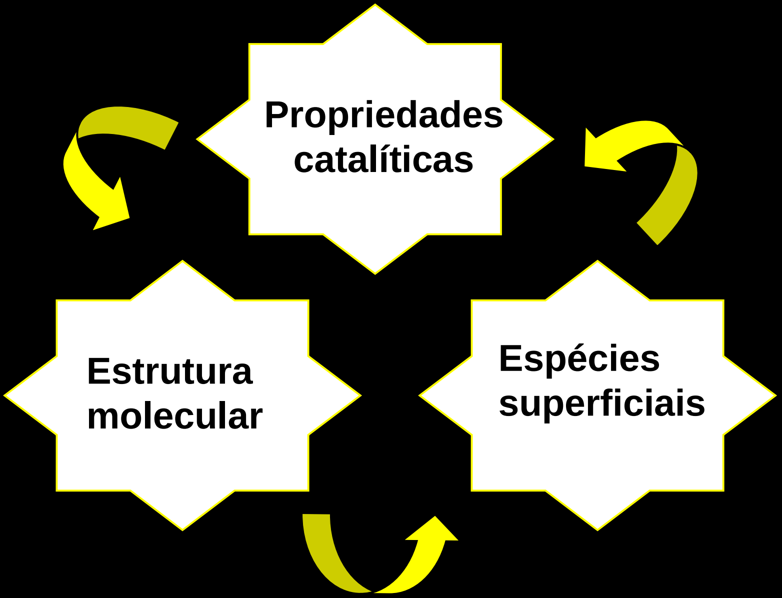
> 500K

$Co^0$-NbOx ⇒ Chain growth ⇒ SMSI

# Caracterização da superfície



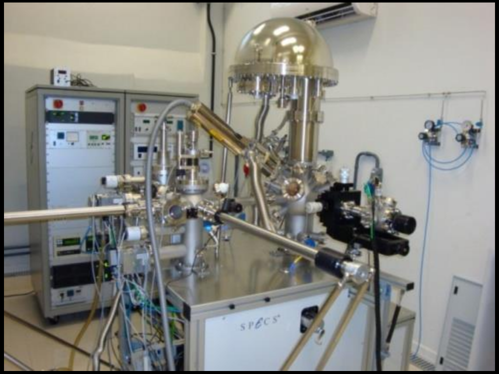


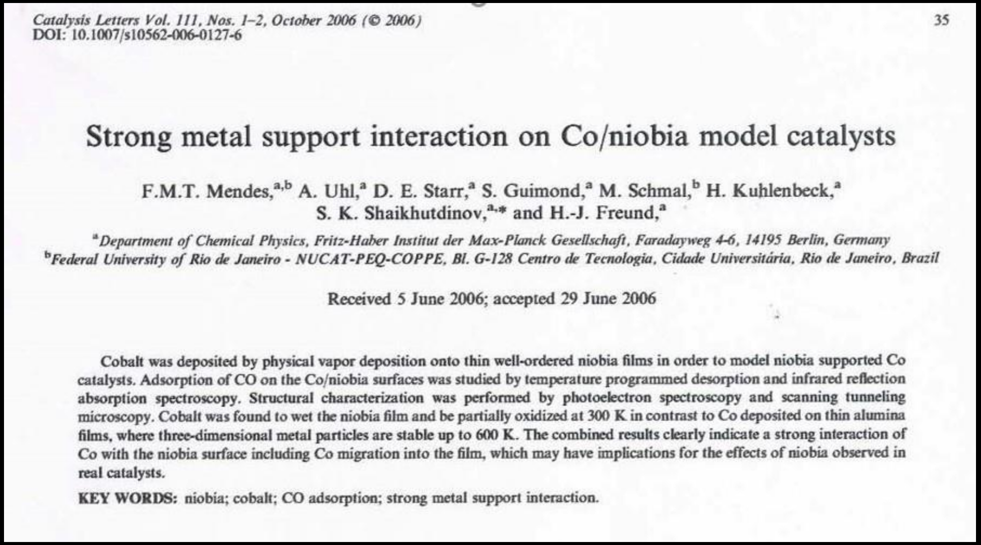


Propriedades catalíticas

Estrutura molecular

Espécies superficiais





*Catalysis Letters Vol. 111, Nos. 1–2, October 2006 (© 2006)*
DOI: 10.1007/s10562-006-0127-6

## Strong metal support interaction on Co/niobia model catalysts

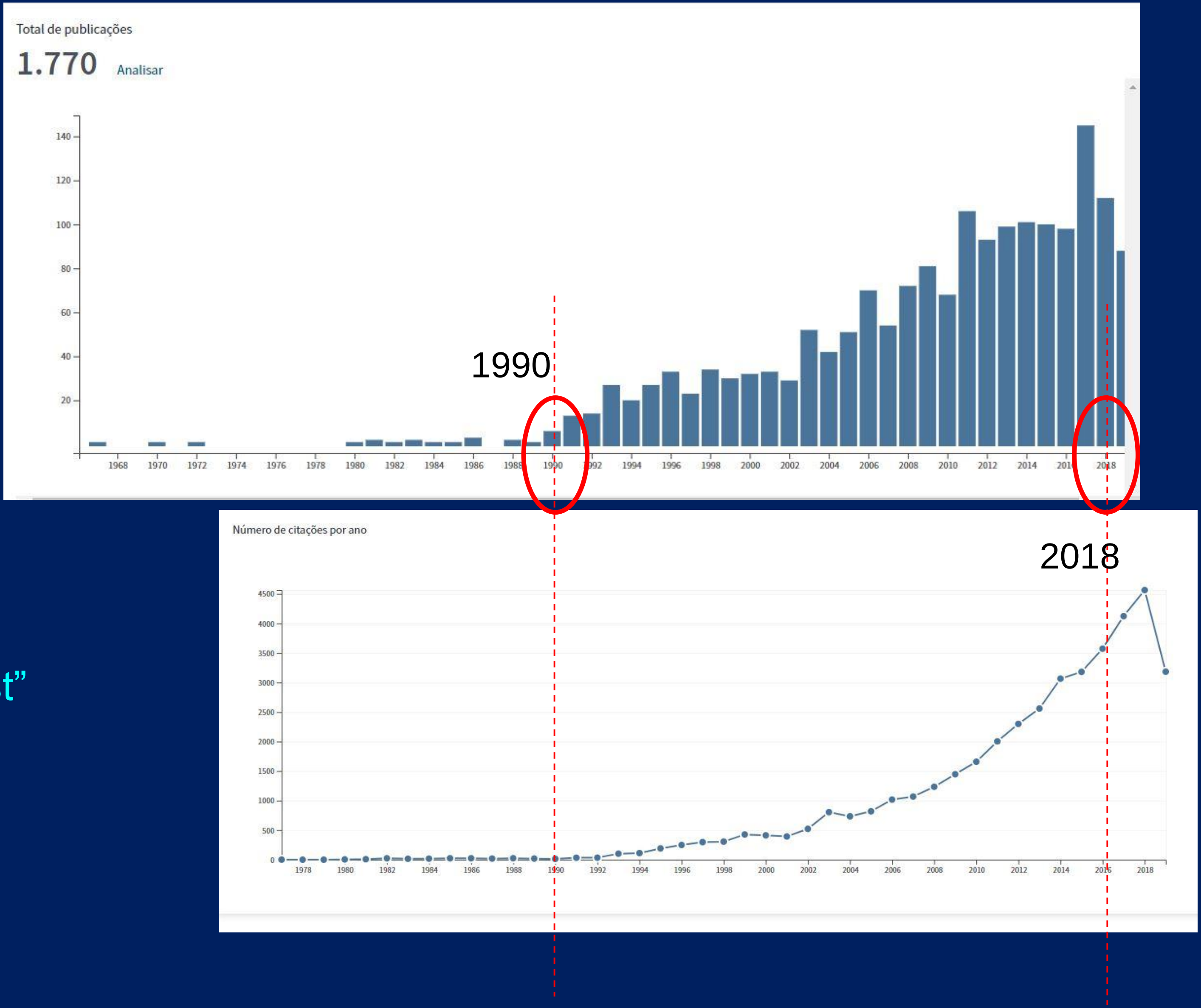
F.M.T. Mendes,[a,b] A. Uhl,[a] D. E. Starr,[a] S. Guimond,[a] M. Schmal,[b] H. Kuhlenbeck,[a]
S. K. Shaikhutdinov,[a,*] and H.-J. Freund,[a]

[a]*Department of Chemical Physics, Fritz-Haber Institut der Max-Planck Gesellschaft, Faradayweg 4-6, 14195 Berlin, Germany*
[b]*Federal University of Rio de Janeiro - NUCAT-PEQ-COPPE, Bl. G-128 Centro de Tecnologia, Cidade Universitária, Rio de Janeiro, Brazil*

Received 5 June 2006; accepted 29 June 2006

Cobalt was deposited by physical vapor deposition onto thin well-ordered niobia films in order to model niobia supported Co catalysts. Adsorption of CO on the Co/niobia surfaces was studied by temperature programmed desorption and infrared reflection absorption spectroscopy. Structural characterization was performed by photoelectron spectroscopy and scanning tunneling microscopy. Cobalt was found to wet the niobia film and be partially oxidized at 300 K in contrast to Co deposited on thin alumina films, where three-dimensional metal particles are stable up to 600 K. The combined results clearly indicate a strong interaction of Co with the niobia surface including Co migration into the film, which may have implications for the effects of niobia observed in real catalysts.

**KEY WORDS:** niobia; cobalt; CO adsorption; strong metal support interaction.



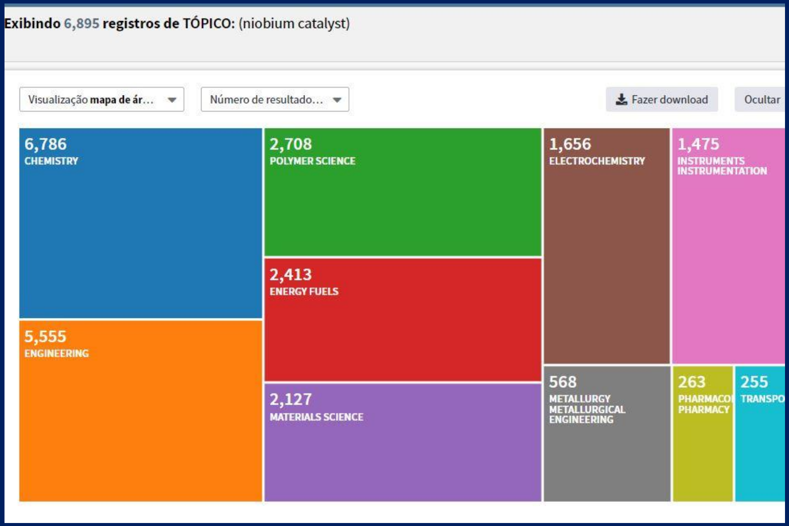
Web of science

“Niobium catalyst”

- 1950 a 2019

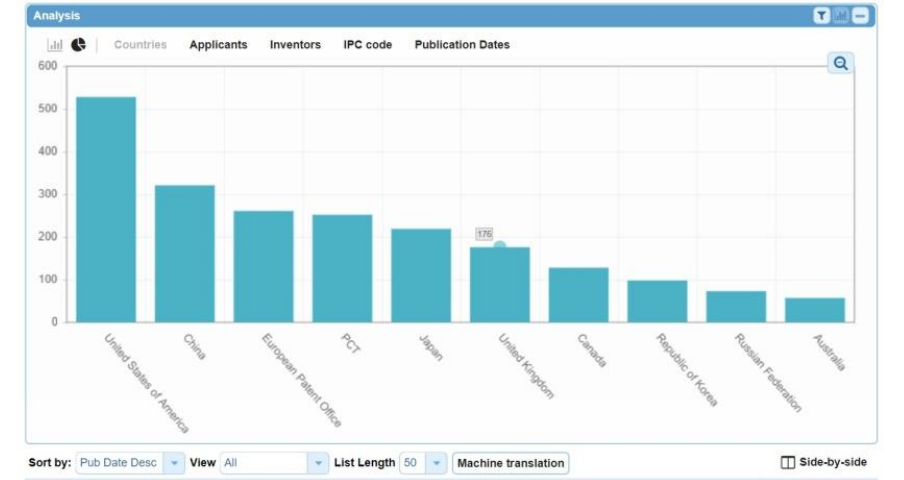
# “Niobium catalyst”

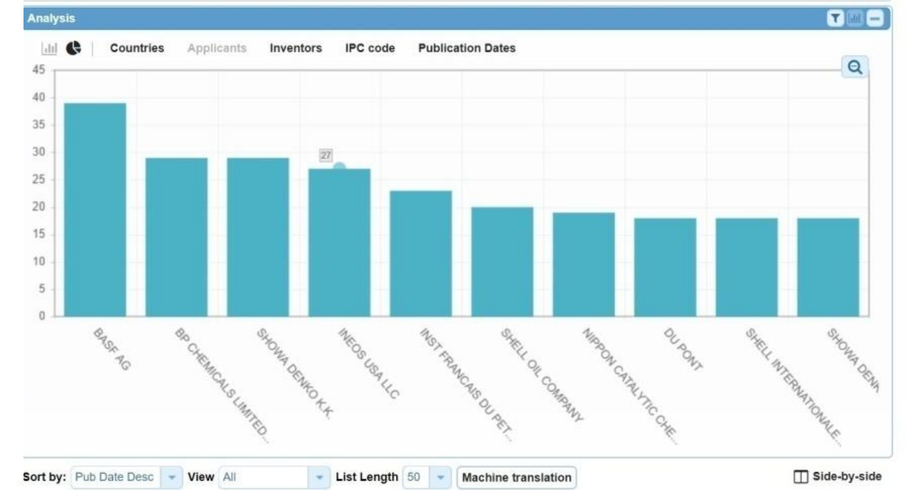
Derwent- 6.875 documentos
Patentscope (WIPO)-2.348 (500-remontam de 2010)
Espacenet- 2.309 documentos



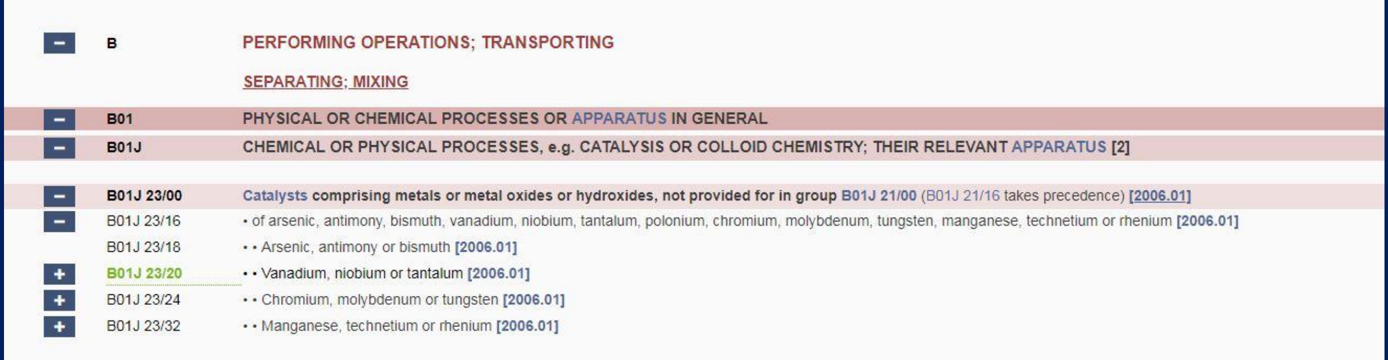
**Exibindo 6,895 registros de TÓPICO:** (niobium catalyst)

Patentscope (WIPO)-2.348

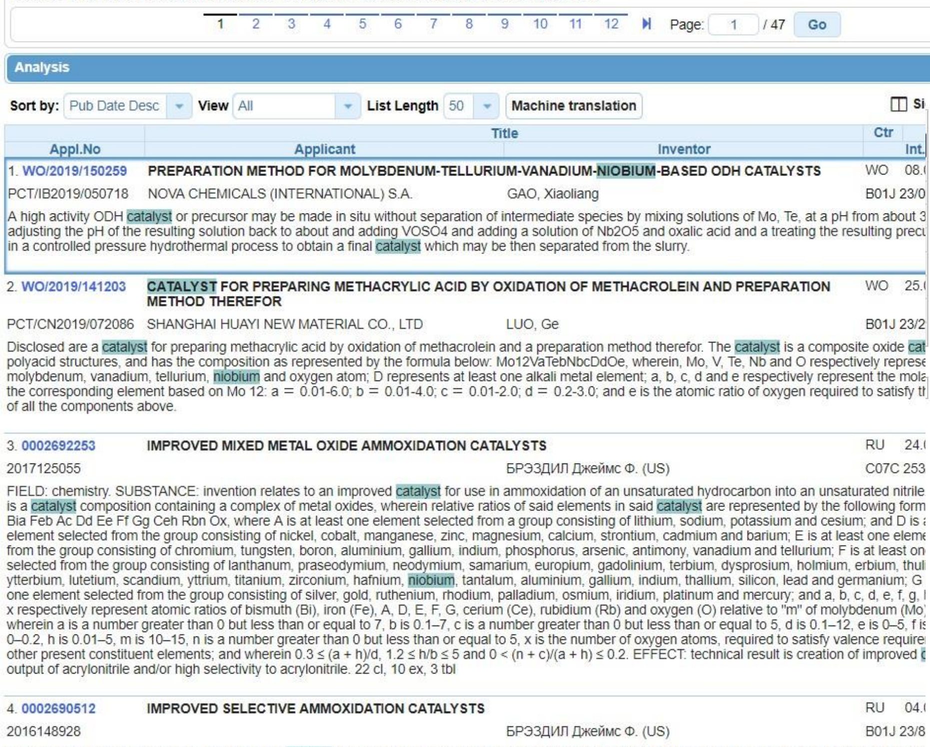




# IPC



| | | |
|---|---|---|
| − | **B** | PERFORMING OPERATIONS; TRANSPORTING |
| | | SEPARATING; MIXING |
| − | **B01** | PHYSICAL OR CHEMICAL PROCESSES OR APPARATUS IN GENERAL |
| − | **B01J** | CHEMICAL OR PHYSICAL PROCESSES, e.g. CATALYSIS OR COLLOID CHEMISTRY; THEIR RELEVANT APPARATUS [2] |
| − | **B01J 23/00** | **Catalysts comprising metals or metal oxides or hydroxides, not provided for in group B01J 21/00** (B01J 21/16 takes precedence) **[2006.01]** |
| − | B01J 23/16 | • of arsenic, antimony, bismuth, vanadium, niobium, tantalum, polonium, chromium, molybdenum, tungsten, manganese, technetium or rhenium **[2006.01]** |
| | B01J 23/18 | • • Arsenic, antimony or bismuth **[2006.01]** |
| + | B01J 23/20 | • • Vanadium, niobium or tantalum **[2006.01]** |
| + | B01J 23/24 | • • Chromium, molybdenum or tungsten **[2006.01]** |
| + | B01J 23/32 | • • Manganese, technetium or rhenium **[2006.01]** |



Results **1-50** of **2,348** for Criteria:**FP:(niobium catalyst)** Office(s):**all** Language:**en** Stemming: **false**

**Sort by:** Pub Date Desc **View** All **List Length** 50

| Appl.No | Title / Applicant | Inventor | Ctr / Int. |
|---|---|---|---|
| 1. **WO/2019/150259**<br>PCT/IB2019/050718 | **PREPARATION METHOD FOR MOLYBDENUM-TELLURIUM-VANADIUM-NIOBIUM-BASED ODH CATALYSTS**<br>NOVA CHEMICALS (INTERNATIONAL) S.A. | GAO, Xiaoliang | WO 08.<br>B01J 23/0 |

A high activity ODH catalyst or precursor may be made in situ without separation of intermediate species by mixing solutions of Mo, Te, at a pH from about 3
adjusting the pH of the resulting solution back to about and adding VOSO4 and adding a solution of Nb2O5 and oxalic acid and a treating the resulting precu
in a controlled pressure hydrothermal process to obtain a final catalyst which may be then separated from the slurry.

| Appl.No | Title / Applicant | Inventor | Ctr / Int. |
|---|---|---|---|
| 2. **WO/2019/141203**<br>PCT/CN2019/072086 | **CATALYST FOR PREPARING METHACRYLIC ACID BY OXIDATION OF METHACROLEIN AND PREPARATION METHOD THEREFOR**<br>SHANGHAI HUAYI NEW MATERIAL CO., LTD | LUO, Ge | WO 25.<br>B01J 23/2 |

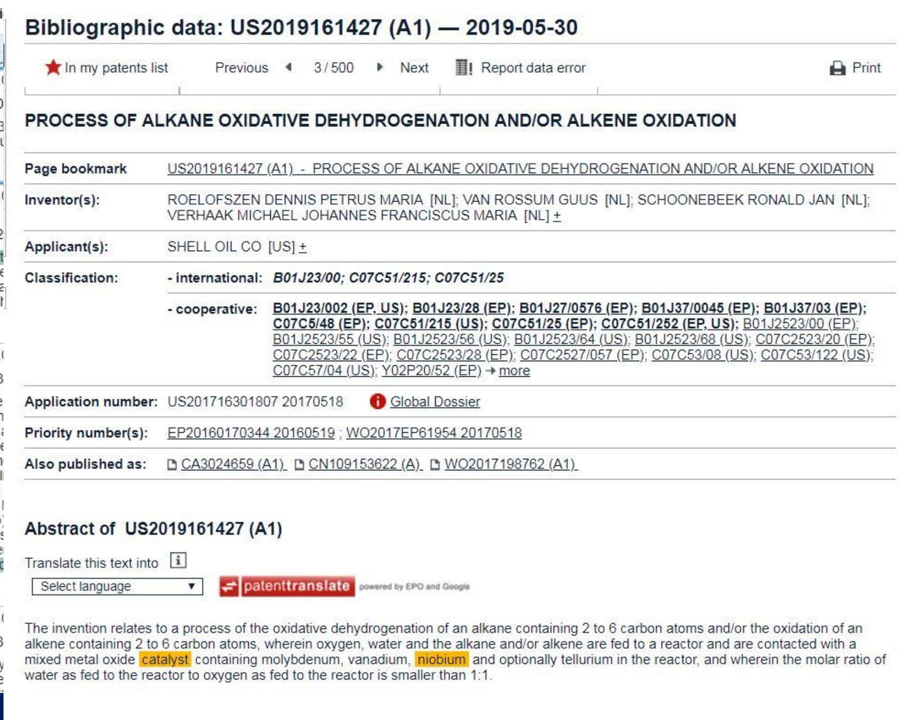
Disclosed are a catalyst for preparing methacrylic acid by oxidation of methacrolein and a preparation method therefor. The catalyst is a composite oxide cat
polyacid structures, and has the composition as represented by the formula below: Mo12VaTebNbcDdOe, wherein, Mo, V, Te, Nb and O respectively represe
molybdenum, vanadium, tellurium, niobium and oxygen atom; D represents at least one alkali metal element; a, b, c, d and e respectively represent the mola
the corresponding element based on Mo 12: a = 0.01-6.0; b = 0.01-4.0; c = 0.01-2.0; d = 0.2-3.0; and e is the atomic ratio of oxygen required to satisfy th
of all the components above.

| Appl.No | Title / Applicant | Inventor | Ctr / Int. |
|---|---|---|---|
| 3. **0002692253**<br>2017125055 | **IMPROVED MIXED METAL OXIDE AMMOXIDATION CATALYSTS** | БРЭЗДИЛ Джеймс Ф. (US) | RU 24.<br>C07C 253 |

FIELD: chemistry. SUBSTANCE: invention relates to an improved catalyst for use in ammoxidation of an unsaturated hydrocarbon into an unsaturated nitrile
is a catalyst composition containing a complex of metal oxides, wherein relative ratios of said elements in said catalyst are represented by the following form
Bia Feb Ac Dd Ee Ff Gg Ceh Rbn Ox, where A is at least one element selected from a group consisting of lithium, sodium, potassium and cesium; and D is
element selected from the group consisting of nickel, cobalt, manganese, zinc, magnesium, calcium, strontium, cadmium and barium; E is at least one eleme
from the group consisting of chromium, tungsten, boron, aluminium, gallium, indium, phosphorus, arsenic, antimony, vanadium and tellurium; F is at least on
selected from the group consisting of lanthanum, praseodymium, neodymium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thul
ytterbium, lutetium, scandium, yttrium, titanium, zirconium, hafnium, niobium, tantalum, aluminium, gallium, indium, thallium, silicon, lead and germanium; G
one element selected from the group consisting of silver, gold, ruthenium, rhodium, palladium, osmium, iridium, platinum and mercury; and a, b, c, d, e, f, g,
x respectively represent atomic ratios of bismuth (Bi), iron (Fe), A, D, E, F, G, cerium (Ce), rubidium (Rb) and oxygen (O) relative to "m" of molybdenum (Mo
wherein a is a number greater than 0 but less than or equal to 7, b is 0.1–7, c is a number greater than 0 but less than or equal to 5, d is 0.1–12, e is 0–5, f is
0–0.2, h is 0.01–5, m is 10–15, n is a number greater than 0 but less than or equal to 5, x is the number of oxygen atoms, required to satisfy valence require
other present constituent elements; and wherein 0.3 ≤ (a + h)/d, 1.2 ≤ h/b ≤ 5 and 0 < (n + c)/(a + h) ≤ 0.2. EFFECT: technical result is creation of improved
output of acrylonitrile and/or high selectivity to acrylonitrile. 22 cl, 10 ex, 3 tbl

| Appl.No | Title / Applicant | Inventor | Ctr / Int. |
|---|---|---|---|
| 4. **0002690512**<br>2016148928 | **IMPROVED SELECTIVE AMMOXIDATION CATALYSTS** | БРЭЗДИЛ Джеймс Ф. (US) | RU 04.<br>B01J 23/8 |

FIELD: chemistry. SUBSTANCE: disclosed is a catalyst composition for increasing selectivity to acrylonitrile during conversion of propylene to acrylonitrile by
a vapour phase at high temperature and pressure of said propylene with a gas containing molecular oxygen, and ammonia and a method for increasing sele



## Bibliographic data: US2019161427 (A1) — 2019-05-30

**PROCESS OF ALKANE OXIDATIVE DEHYDROGENATION AND/OR ALKENE OXIDATION**

| | | |
|---|---|---|
| **Page bookmark** | US2019161427 (A1) - PROCESS OF ALKANE OXIDATIVE DEHYDROGENATION AND/OR ALKENE OXIDATION | |
| **Inventor(s):** | ROELOFSZEN DENNIS PETRUS MARIA [NL]; VAN ROSSUM GUUS [NL]; SCHOONEBEEK RONALD JAN [NL]; VERHAAK MICHAEL JOHANNES FRANCISCUS MARIA [NL] + | |
| **Applicant(s):** | SHELL OIL CO [US] + | |
| **Classification:** | **- international:** | ***B01J23/00; C07C51/215; C07C51/25*** |
| | **- cooperative:** | **B01J23/002 (EP, US); B01J23/28 (EP); B01J27/0576 (EP); B01J37/0045 (EP); B01J37/03 (EP); C07C5/48 (EP); C07C51/215 (US); C07C51/25 (EP); C07C51/252 (EP, US);** B01J2523/00 (EP); B01J2523/55 (US); B01J2523/56 (US); B01J2523/64 (US); B01J2523/68 (US); C07C2523/20 (EP); C07C2523/22 (EP); C07C2523/28 (EP); C07C2527/057 (EP); C07C53/08 (US); C07C53/122 (US); C07C57/04 (US); Y02P20/52 (EP) → more |
| **Application number:** | US201716301807 20170518 Global Dossier | |
| **Priority number(s):** | EP20160170344 20160519 ; WO2017EP61954 20170518 | |
| **Also published as:** | CA3024659 (A1) CN109153622 (A) WO2017198762 (A1) | |

### Abstract of US2019161427 (A1)

Translate this text into

The invention relates to a process of the oxidative dehydrogenation of an alkane containing 2 to 6 carbon atoms and/or the oxidation of an alkene containing 2 to 6 carbon atoms, wherein oxygen, water and the alkane and/or alkene are fed to a reactor and are contacted with a mixed metal oxide catalyst containing molybdenum, vanadium, niobium and optionally tellurium in the reactor, and wherein the molar ratio of water as fed to the reactor to oxygen as fed to the reactor is smaller than 1:1.

# Oxidação parcial do n-butano à anidrido maleico

## Bibliographic data: WO2005025742 (A1) — 2005-03-24

### NIOBIUM-DOPED VANADIUM/PHOSPHORUS MIXED OXIDE CATALYST

**Page bookmark** WO2005025742 (A1) - NIOBIUM-DOPED VANADIUM/PHOSPHORUS MIXED OXIDI

**Inventor(s):** GHELFI FEDERICO [IT]; MAZZONI GIANLUCA [IT]; FUMAGALLI CARLO [IT]; CAVA
FRANCESCA [IT] +

**Applicant(s):**

**Classification:**

**Application num**

**Priority number(**

**Also published a**

**Abstract of V**

Translate this text

Select language

Disclosed is a pro
maleic anhydride.
corresponding to a
maleic anhydride,

**International search citation**

☐ 1. Preparation of improved mixed vanadium phosphorus oxide catalysts and their use

| Inventor: | Applicant: | CPC: | IPC: |
|---|---|---|---|
| DRIA DENNIS EDWARD [US]<br>BREMER NOEL JEROME [US] | STANDARD OIL CO OHIO [US] | B01J23/002<br>B01J2523/00<br>B01J2523/51<br>(+12) | B01J27/198<br>C01B25/37<br>C07B61/00<br>(+7) |

☐ 2. VANADIUM/PHOSPHORUS MIXED OXIDE CATALYST PRECURSOR

| Inventor: | Applicant: | CPC: | IPC: |
|---|---|---|---|
| ALBONETTI STEFANIA [IT]<br>CAVANI FABRIZIO [IT]<br>(+2) | LONZA SPA [IT]<br>ALBONETTI STEFANIA [IT]<br>(+3) | B01J23/002<br>B01J2523/00<br>B01J2523/51<br>(+7) | B01J27/198<br>B01J31/02<br>B01J37/08<br>(+7) |

☐ 3. Process for the tranformation of a vanadium/Phosphorous Mixed Oxide catalyst precursor into the active catalyst for the production of maleic anhydride

| Inventor: | Applicant: | CPC: | IPC: | Publication info: | Priority dat |
|---|---|---|---|---|---|
| MAZZONI GIANLUCA [IT]<br>CAVANI FABRIZIO [IT]<br>(+1) | LONZA SPA [IT] | B01J23/002<br>B01J2523/00<br>B01J2523/51<br>(+6) | B01J27/198<br>B01J27/199<br>C07B61/00<br>(+5) | EP0804963 (A1)<br>1997-11-05<br>EP0804963 (B1)<br>2000-01-05 | 1996-04-29 |

**International search NPL citation**

☐ 4. Vanadium Phosphorus Oxide Catalyst Modified by Niobium Doping for Mild Oxidation of n-Butane to Maleic Anhydride

| Author: | Publication data: | CPC: | Source information: | Publication info: |
|---|---|---|---|---|
| Duarte de Farias A M<br>Gonzalez W d A<br>Pries de Oliveira P G<br>Eon J-G<br>Herrmann J-M<br>Aouine M<br>Loridant S<br>Volta J-C | JOURNAL OF CATALYSIS, 20020515 ACADEMIC PRESS, DULUTH, MN, US | | Vol:208,Nr:1,Page(s):238 - 246 | XP004465725 |

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República Federativa do Brasil
Ministério do Desenvolvimento, Indústria e do Comércio Exterior
Instituto Nacional da Propriedade Industrial

(11) **PI0011129-5 B1**

(22) Data de Depósito: 30/05/2000
**(45) Data da Concessão: 20/09/2011**
**(RPI 2124)**

***(51) Int.Cl.:***
**B01J 27/198**
**B01J 31/02**
**C07C 51/215**

(54) Título: **PRECURSOR DE CATALISADOR DE ÓXIDO DE VANÁDIO / FÓSFORO MISTURADOS, PROCESSO PARA PREPARAÇÃO DO MESMO, CATALISADOR ATIVO E PROCESSO PARA PRODUÇÃO DE ANIDRIDO MALÉICO.**

(30) Prioridade Unionista: 01/06/1999 IT MI99 A 001233

(73) Titular(es): Lonza S.p.A.

(72) Inventor(es): Fabrizio Cavani, Gianluca Mazzoni, Simone Ligi, Stefania Albonetti

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Catalysis Today
Volume 57, Issues 3–4, 20 April 2000, Pages 177-186

## Modification of vanadium phosphorus oxides used for *n*-butane oxidation to maleic anhydride by interaction with niobium phosphate

P.G Pries de Oliveira [a], J.G Eon [b], M Chavant [c], A.S Riché [c], V Martin [c], S Caldarelli [c], J.C Volta [c]

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https://doi.org/10.1016/S0920-5861(99)00324-7

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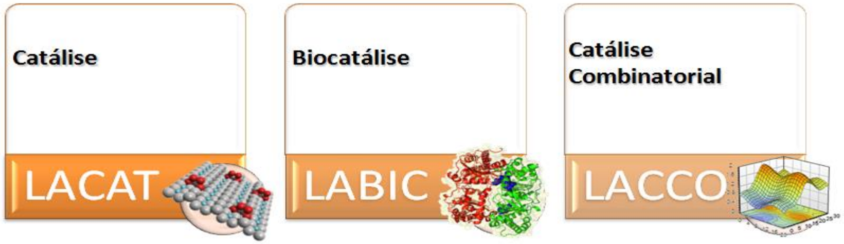
# Instituto Nacional de Tecnologia – INT- 1921

Ernesto da Fonseca Costa: Estação Experimental de Combustíveis e Minérios



**Catálise**

LACAT

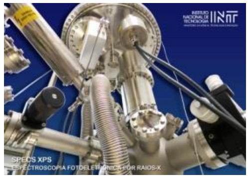
**Biocatálise**

LABIC

**Catálise Combinatorial**

LACCO

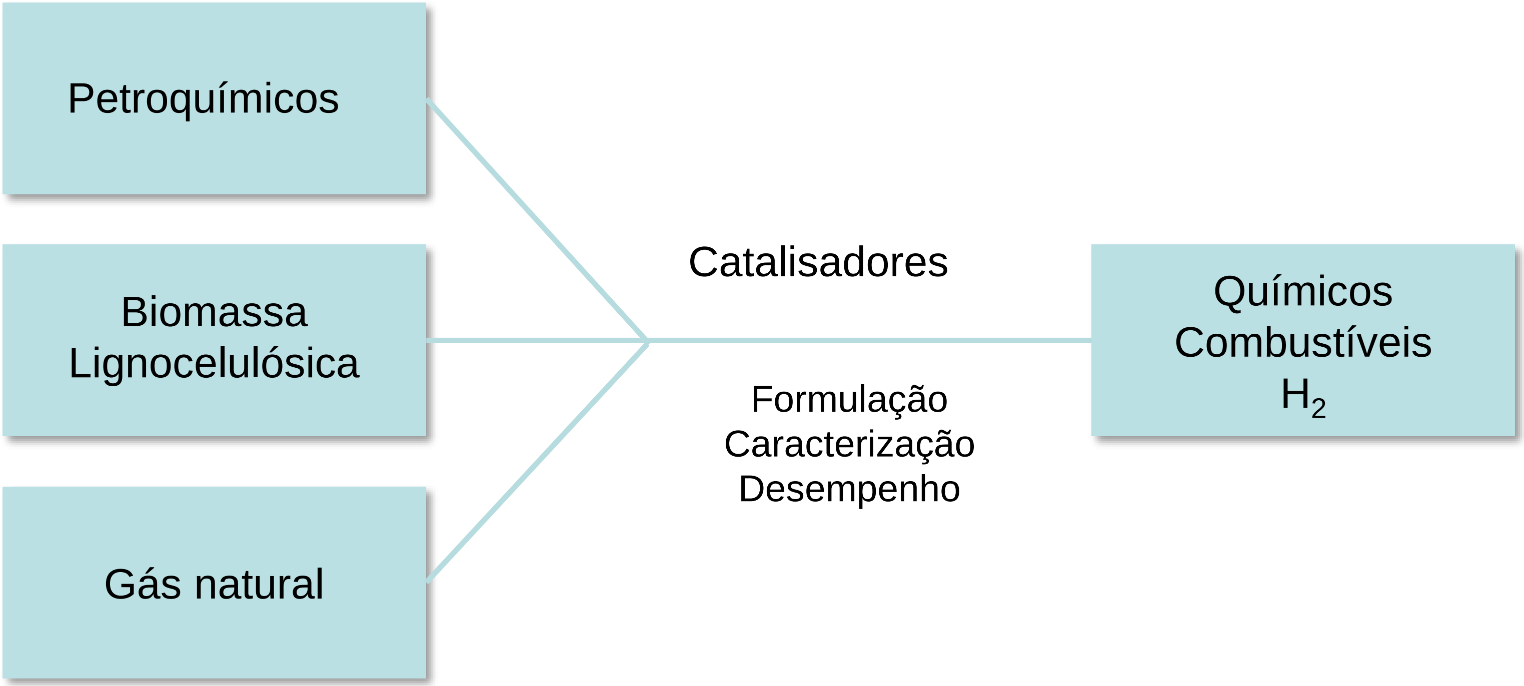
CENANO



Materiais e Catálise

# Atividades em P&D&I

**Desenvolvimento tecnológico para os setores de energia e produtos químicos através de atividades avançadas de P&D&I em Catálise e Biocatálise.**



Petroquímicos

Biomassa Lignocelulósica

Gás natural

Catalisadores

Formulação
Caracterização
Desempenho

Químicos
Combustíveis
$H_2$

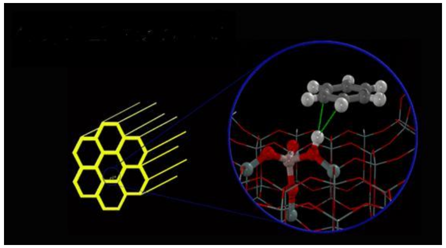
# Conversão do propano: ainda um desafio

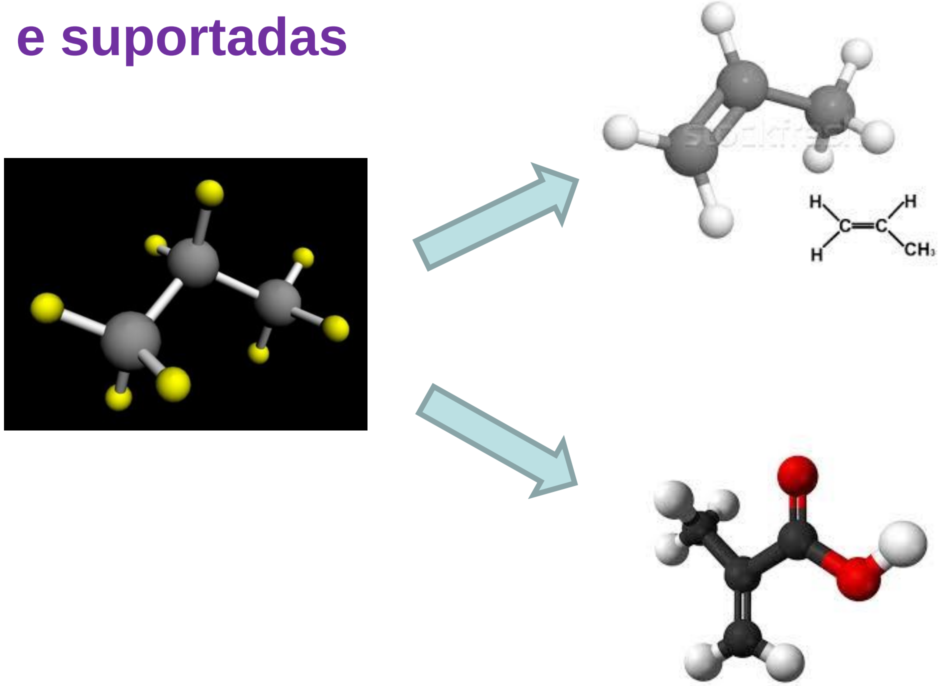
ODH e oxidação seletiva de propano

- ✓**Seletividade e eficiência**
- ✓**Controle da combustão total**
- ✓**Estabilidade**

Cs, V, Nb, Mo, Te

## Estruturas modificadas e suportadas





**Carvão ativado como suporte-Palha e Bagaço da cana de açúcar**


International Conference on

Applied Catalysis & Chemical Engineering

April 8-10, 2019 | Dubai, UAE

# Propane ODH

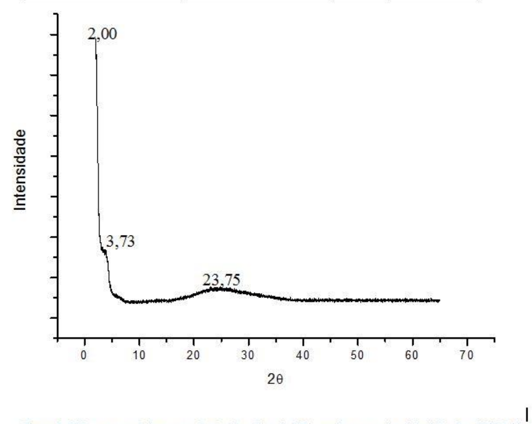
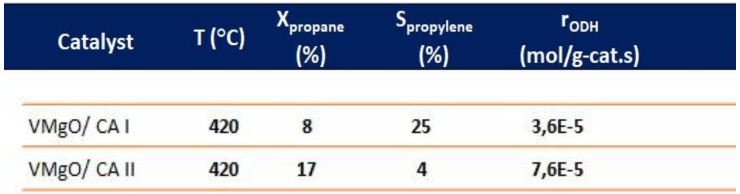
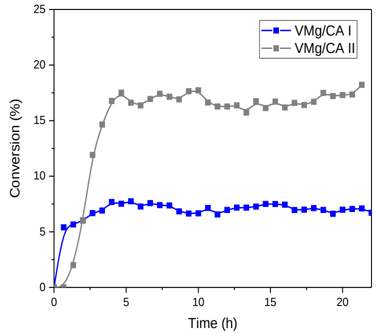


Figura 8: Difratograma da impregnação úmida refeita de 10%complexo amoniacal de nióbio I na MCM-41.

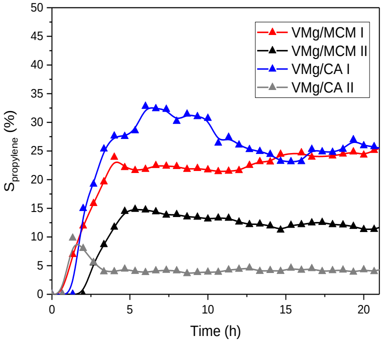


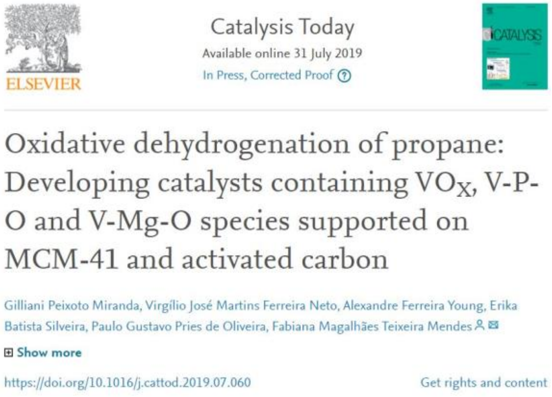
| Catalyst | T (°C) | $X_{propane}$ (%) | $S_{propylene}$ (%) | $r_{ODH}$ (mol/g-cat.s) |
|---|---|---|---|---|
| VMgO/ CA I | 420 | 8 | 25 | 3,6E-5 |
| VMgO/ CA II | 420 | 17 | 4 | 7,6E-5 |

$$r'_{ODH} = \frac{N^o_{propane}}{W_{cat}} \frac{X_{propane}}{t} \left(\frac{mol}{g\,s}\right)$$



- A presença do Mg atua na estabilização
- A presença do Nb no sistema está sendo avaliada




ELSEVIER

Catalysis Today

Available online 31 July 2019

In Press, Corrected Proof

Oxidative dehydrogenation of propane: Developing catalysts containing $VO_X$, V-P-O and V-Mg-O species supported on MCM-41 and activated carbon

Gilliani Peixoto Miranda, Virgílio José Martins Ferreira Neto, Alexandre Ferreira Young, Erika Batista Silveira, Paulo Gustavo Pries de Oliveira, Fabiana Magalhães Teixeira Mendes

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https://doi.org/10.1016/j.cattod.2019.07.060

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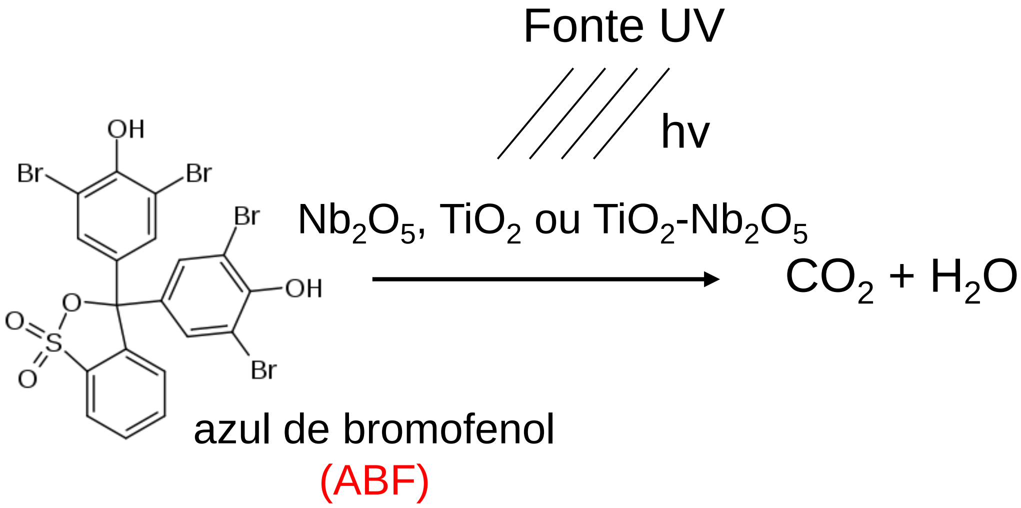
# Aplicações em fotocatálise

- Remoção dos orgânicos: adsorção em carvão ativado, filtração por membranas, etc.
- Mineralização desses compostos através de processos oxidativos avançados (POA).
- Óxidos semicondutores ($TiO_2$, ZnO, $Nb_2O_5$, etc): fotocatalisadores.



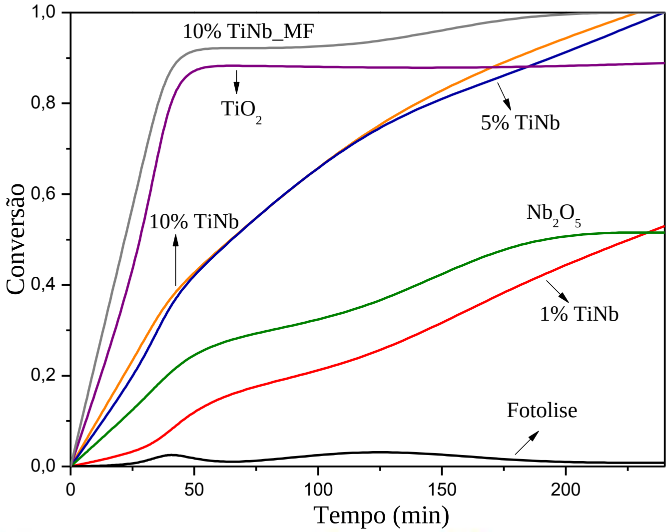
Fonte UV

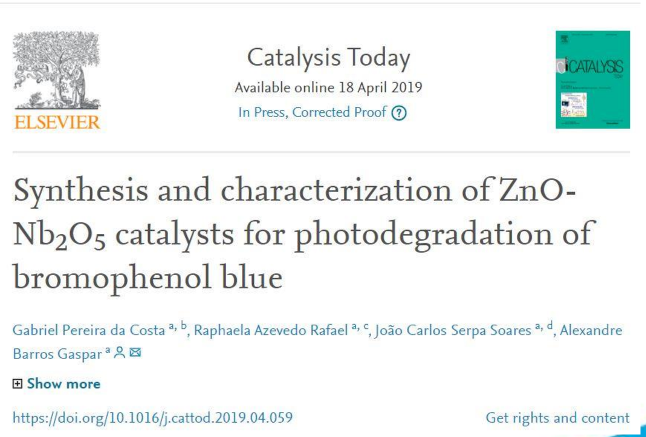
hv

$$\text{ABF} \xrightarrow{Nb_2O_5,\ TiO_2 \text{ ou } TiO_2\text{-}Nb_2O_5} CO_2 + H_2O$$

azul de bromofenol
(ABF)

Mistura física 10% TiNb_MF alcança 100% de conversão do ABF ⇒ presença do $Nb_2O_5$ retarda a recombinação dos pares elétron-vacância do $TiO_2$.





Catalysis Today
Available online 18 April 2019
In Press, Corrected Proof ⓘ

Synthesis and characterization of ZnO-$Nb_2O_5$ catalysts for photodegradation of bromophenol blue

Gabriel Pereira da Costa [a, b], Raphaela Azevedo Rafael [a, c], João Carlos Serpa Soares [a, d], Alexandre Barros Gaspar [a]

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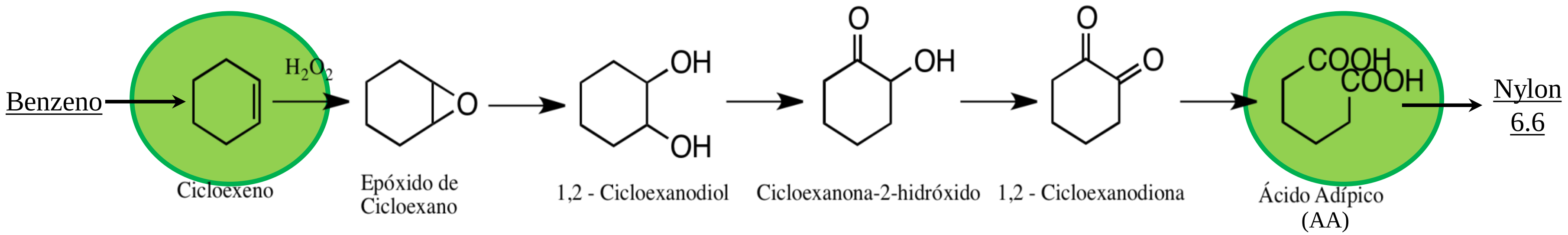
https://doi.org/10.1016/j.cattod.2019.04.059 Get rights and content

# Aplicações em oxidação

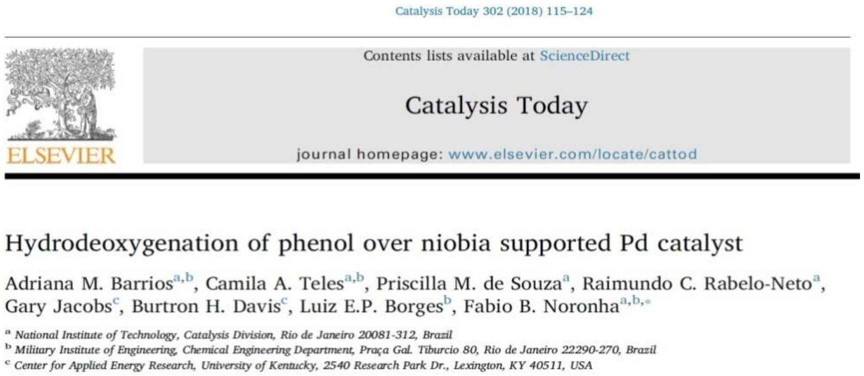


Agente oxidante: $HNO_3 \cancel{\longrightarrow} N_2O$ gás de efeito estufa

$H_2O_2 \longrightarrow H_2O$ 👍

| Catalisador | T trat. (ºC) | Acidez (μmol.g$^{-1}$) | Rendimento (%) | | |
|---|---|---|---|---|---|
| | | | Diol | AA | Outros |
| **$Nb_2O_5$** | 200 | 2800 | 31 | 0 | 69 |
| **$NbOPO_4$ 1** | 200 | 3480 | 68 | 11 | 22 |
| **$NbOPO_4$ 2** | 250 | 3090 | 72 | 5 | 23 |

- 20ºC Congresso Brasileiro de Catálise, 2019



Catalysis Today 302 (2018) 115–124

Contents lists available at ScienceDirect

Catalysis Today

journal homepage: www.elsevier.com/locate/cattod

## Hydrodeoxygenation of phenol over niobia supported Pd catalyst

Adriana M. Barrios[a,b], Camila A. Teles[a,b], Priscilla M. de Souza[a], Raimundo C. Rabelo-Neto[a], Gary Jacobs[c], Burtron H. Davis[c], Luiz E.P. Borges[b], Fabio B. Noronha[a,b,*]

[a] National Institute of Technology, Catalysis Division, Rio de Janeiro 20081-312, Brazil
[b] Military Institute of Engineering, Chemical Engineering Department, Praça Gal. Tiburcio 80, Rio de Janeiro 22290-270, Brazil
[c] Center for Applied Energy Research, University of Kentucky, 2540 Research Park Dr., Lexington, KY 40511, USA

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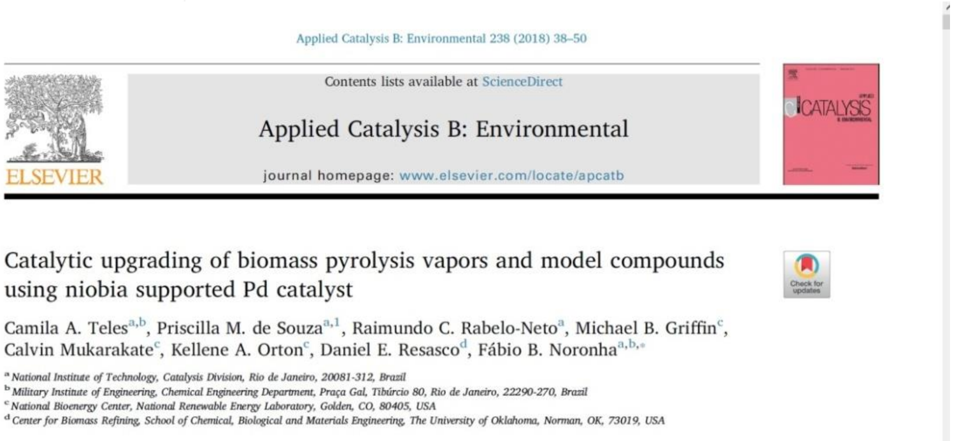

Applied Catalysis B: Environmental 238 (2018) 38–50

Contents lists available at ScienceDirect

Applied Catalysis B: Environmental

journal homepage: www.elsevier.com/locate/apcatb

## Catalytic upgrading of biomass pyrolysis vapors and model compounds using niobia supported Pd catalyst

Camila A. Teles[a,b], Priscilla M. de Souza[a,1], Raimundo C. Rabelo-Neto[a], Michael B. Griffin[c], Calvin Mukarakate[c], Kellene A. Orton[c], Daniel E. Resasco[d], Fábio B. Noronha[a,b,*]

[a] National Institute of Technology, Catalysis Division, Rio de Janeiro, 20081-312, Brazil
[b] Military Institute of Engineering, Chemical Engineering Department, Praça Gal, Tibúrcio 80, Rio de Janeiro, 22290-270, Brazil
[c] National Bioenergy Center, National Renewable Energy Laboratory, Golden, CO, 80405, USA
[d] Center for Biomass Refining, School of Chemical, Biological and Materials Engineering, The University of Oklahoma, Norman, OK, 73019, USA

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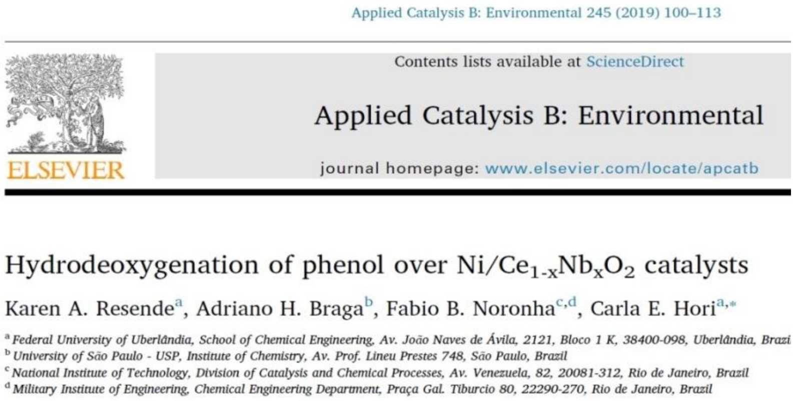

Applied Catalysis B: Environmental 245 (2019) 100–113

Contents lists available at ScienceDirect

Applied Catalysis B: Environmental

journal homepage: www.elsevier.com/locate/apcatb

## Hydrodeoxygenation of phenol over Ni/$Ce_{1-x}Nb_xO_2$ catalysts

Karen A. Resende[a], Adriano H. Braga[b], Fabio B. Noronha[c,d], Carla E. Hori[a,*]

[a] Federal University of Uberlândia, School of Chemical Engineering, Av. João Naves de Ávila, 2121, Bloco 1 K, 38400-098, Uberlândia, Brazi
[b] University of São Paulo - USP, Institute of Chemistry, Av. Prof. Lineu Prestes 748, São Paulo, Brazil
[c] National Institute of Technology, Division of Catalysis and Chemical Processes, Av. Venezuela, 82, 20081-312, Rio de Janeiro, Brazil
[d] Military Institute of Engineering, Chemical Engineering Department, Praça Gal. Tiburcio 80, 22290-270, Rio de Janeiro, Brazil

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Heterogeneous & Homogeneous & Bio- & Nano-
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Full Paper

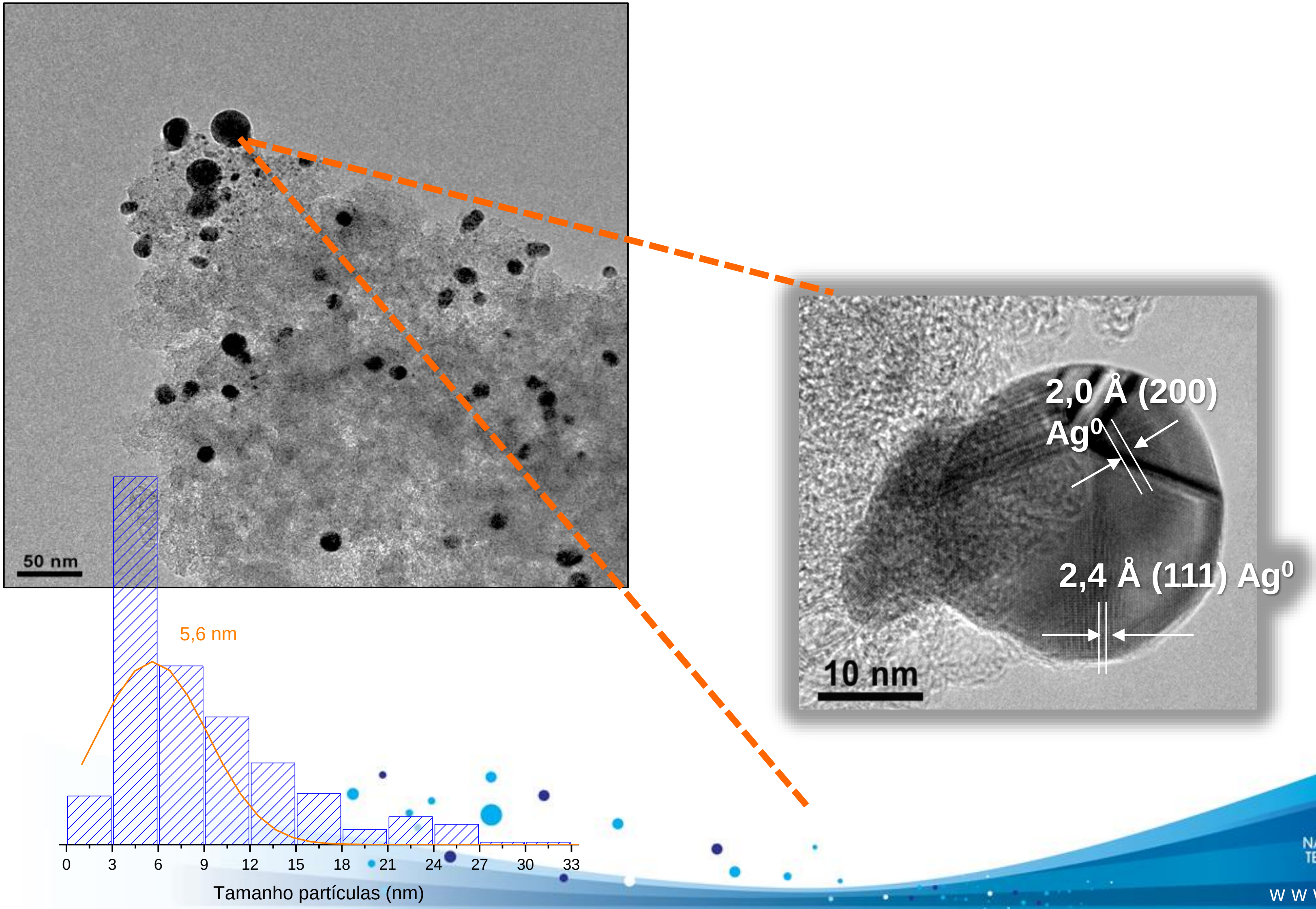
## The Role of Brønsted and Water-Tolerant Lewis Acid Sites in the Cascade Aqueous-Phase Reaction of Triose to Lactic Acid

Kryslaine M. A. Santos, Dr. Elise M. Albuquerque, Dr. Giada Innocenti, Prof. Luiz E. P. Borges, Prof. Carsten Sievers, Prof. Marco A. Fraga ✉

First published: 20 May 2019 | https://doi.org/10.1002/cctc.201900519

# Conversão de $CO_2$ a CO por processos eletrocatalíticos: Desenvolvimento e caracterização de nanopartículas suportadas em CA.

**Ag NP/CA** **Tecnologia da água** NP_Nb/CA em andamento



# A cada passo dado, um novo desafio...

Conhecimento:
P&D

Maturidade
tecnológica

Obrigada!


'03 4 1