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**CONTENTS / СОДЕРЖАНИЕ**

**Viktor F. Odyakov and Elena G. Zhizhina**

Products of Homogeneous Two-Stage Oxidation of 1-Butene to  
Butanone with O<sub>2</sub> Over the Catalyst Pd + Heteropoly Acid

— 221 —

**Sergey M. Zharkov, Evgeny T. Moiseenko,**

**Roman R. Altunin and Galina M. Zeer**

*In situ* transmission electron microscopy and electron diffraction  
investigation of solid-state reactions and atomic ordering in  
Cu/Au bilayer nanofilms

— 230 —

**В.И. Шарыпов, Н.Г. Береговцова,**

**С.В. Барышников, Б.Н. Кузнецов,**

**А.В. Восьмериков, О.П. Таран, В.Е. Агабеков**

Термическая конверсия лигнина древесины осины в этаноле  
в присутствии цеолитных катализаторов

— 241 —

**Т.Г. Шендрик, В.А. Кучеренко, В.В. Симонова**

Конверсия химически модифицированных углей и  
углеродсодержащих отходов в жидкие продукты

— 251 —

**О.П. Таран, А.Б. Аюшеев, О.Л. Огородникова,**

**И.П. Просвирина, Л.А. Исупова**

Перовскитоподобные катализаторы типа LaBO<sub>3</sub> (B = Cu,  
Fe, Mn, Co, Ni) для глубокого жидкофазного окисления  
фенола пероксидом водорода

— 266 —

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**Б.Н. Кузнецов, Н.В. Чесноков,  
Н.В. Гарынцева, О.В. Яценкова**

Интегрированная каталитическая переработка древесины осины в жидкие и твердые биотоплива

— 286 —

**Л.Т. Денисова, Л.Г. Чумилина, В.М. Денисов**

Теплоемкость оксидных соединений систем оксид бария — оксид железа и оксид кальция — оксид висмута

— 299 —

**В.И. Кузьмин, Д.В. Кузьмин, А.М. Жижаев**

Изучение вещественного состава и технологических свойств редкометалльных руд Чукотского месторождения

— 303 —

**Л.Г. Бондарева, А.С. Жук, В.В. Сурсякова,  
А.И. Рубайло, Н.И. Тананаев, И.Г. Тананаев**

Химико-экологическое состояние района г. Игарка Красноярского края

— 313 —

**Ю.А. Тюлькова, Т.В. Рязанова,**

**О.Н. Еременко, С.В. Ушанов**

Моделирование процесса экстракции коры сосны водно-щелочным раствором

— 321 —

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## Products of Homogeneous Two-Stage Oxidation of 1-Butene to Butanone with O<sub>2</sub> Over the Catalyst Pd + Heteropoly Acid

**Viktor F. Odyakov and Elena G. Zhizhina\****Boriskov Institute of Catalysis,  
5 Lavrentieva, Novosibirsk, 630090 Russia*

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*Oxidation of 1-butene to butanone in the presence of homogeneous catalyst Pd + HPA (H<sub>12</sub>P<sub>3</sub>Mo<sub>18</sub>V<sub>7</sub>O<sub>83</sub>) followed by regeneration of the catalyst with O<sub>2</sub> proceeds with selectivity 97.5 %. Side products of the process are acetic acid (1.4 %) and condensed compounds C<sub>7</sub>H<sub>12</sub>O<sub>2</sub>, C<sub>8</sub>H<sub>14</sub>O<sub>2</sub>, C<sub>6</sub>H<sub>6</sub>O<sub>2</sub>, and C<sub>8</sub>H<sub>10</sub>O<sub>2</sub> (total 1.1 %). In the course of the catalyst regeneration at 170 °C under O<sub>2</sub> pressure, the compounds C<sub>6</sub>–C<sub>8</sub> are completely oxidized to CO<sub>2</sub> and acetic acid. n-Butanal is absent in the reaction products, that permits readily to separate butanone as a water azeotrope from the reduced catalyst.*

*Keywords: Oxidation of 1-butene to butanone, homogeneous catalyst Pd + HPA, reaction products.*

### Introduction

The processes of oxidation of lower alkenes C<sub>2</sub>–C<sub>4</sub> to carbonyl compounds with dioxygen by reaction (1) are of great practical importance:



Here R = H, CH<sub>3</sub>, or C<sub>2</sub>H<sub>5</sub>. In the late 1950s the Wacker company had suggested for such processes a homogeneous catalyst, which was an aqueous solution of PdCl<sub>2</sub> + CuCl<sub>2</sub> [1, 2]. CuCl<sub>2</sub> here is a reversible oxidant, which reduced form is readily oxidized with dioxygen. Such catalyst had a high concentration of chlorides (up to 2 M), that led to formation of toxic chloroorganic side products. Their amount strongly increased in the series C<sub>2</sub> (ca. 2 % [3]) < C<sub>3</sub> (ca. 4 %) < C<sub>4</sub> (> 6 %) [2, 4]. Amount of chloroorganics strongly increased also at elevated temperature [4] but decreased after dehydrochlorination (see later). Besides, various amounts of aldehydes, RCH<sub>2</sub>CHO, were formed together with ketones, CH<sub>3</sub>COR. When propene or 1-butene were oxidized, yield of RCH<sub>2</sub>CHO varied from 3 to 18 % [2, 5]. Only in oxidation of 2-butene, butanone was the single reaction product [1]. Now

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\* Corresponding author E-mail address: zhizh@catalysis.ru