

A.S. Chernenko, V.V. Kalinchak, A.K. Kopyyka, M.V. Roziznanyi, A.V. Fedorenko

Catalytic oxidation of acetone and ethanol on a platinum wire

Odesa I.I. Mechnikov National University Odesa, Ukraine, tephys@onu.edu.ua

The current-voltage characteristics of a thin long platinum wire in air with small admixtures of acetone or ethanol vapors were obtained. Using the quadratic dependence of platinum resistance on temperature, the temperature-current dependences for the wire were calculated. At concentrations of combustible gas vapors above a certain value, these dependences show a hysteretic character. Using the assumption of complete oxidation of acetone and ethanol on platinum, as a catalyst, and the first order of the oxidation reaction, an analysis of temperature-current dependences was performed. The temperature difference between the high and low-temperature stationary modes of catalytic oxidation on the wire makes it possible to estimate the concentration of the impurity in the mixture. As a result, the experimental dependence of the critical value of the catalytic current ignition and the extinguishing of the gas mixture on platinum on the impurity concentration was constructed. With its analytical description, it is possible to fairly accurately estimate the apparent values of the activation energy and the pre-exponential factor of the oxidation reaction in a wide temperature range. A method of determining the kinetic parameters of the oxidation reaction based on the experimentally found parameters of the degeneracy of critical conditions is proposed.

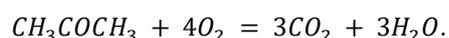
Key words: catalyst, platinum wire, diameter, small admixture of gas, acetone, ethanol, ignition, extinction, combustion.

Received 12 September 2023; Accepted 8 March 2023.

Introduction

Pure metals, especially platinum, are the most common catalysts for the oxidation of volatile organic compounds. Platinum nanoparticles are often added to the surface of the oxide catalyst, which significantly accelerates the oxidation of the compound [1-4].

The work [5] investigated the kinetics of catalytic combustion of acetone and toluene at low concentrations in air (partial pressure from 10 to 101 Pa) on $Cu_{0.13}Ce_{0.87}O_y$ catalysts at temperatures from 423 to 483 K. The reaction order and activation energy for acetone combustion are visible and toluene over the catalyst varied depending on the partial pressure of the impurity at the inlet and the reaction temperature, respectively. It was assumed here that the catalytic combustion of acetone in air proceeds according to the gross reaction:



The thermal effect of the reaction is 1829.4 kJ/mol.

The obtained activation energy of the acetone oxidation reaction is 96-109 kJ/mol.

The current characteristics and oxidation of acetone vapors in a corona discharge of atmospheric pressure in the wire-plate system were investigated in [6]. Here, the authors assumed the reaction of complete oxidation of acetone. However, it was also believed that the oxidation of acetone can follow a parallel reaction of incomplete oxidation:



The thermal effect of reaction (II) is 973 kJ/mol.

The authors [7] propose a mechanism for the complete oxidation of acetone on a catalyst of 0.57 wt.% CeO_2 -0.05 wt.% Pt/TiO_2 . Molecules of acetone and oxygen were initially adsorbed on the catalyst. After the reaction temperature increases, acetone decomposes into acetic and formic acids, then these acids turn into carbonate particles. Finally, these particles completely decompose to CO_2 and

H_2O .

The oxidation of acetone on platinum was assumed to be complete, i.e. to CO_2 , and in [4]. At the same time, the concept of low temperatures (up to 300 °C) is introduced for such a process.

Platinum is the earliest catalyst for single-component catalysis in the ethanol oxidation reaction [8, 9]. The authors [8] indicate that such oxidation can be complete (with slow oxidation) to CO_2 and partial to acetaldehyde or acid.

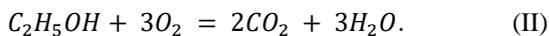
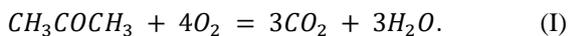
The authors [10] indicate a high percentage (over 90%) of CO_2 formation during the oxidation of methanol and ethanol on a platinum catalyst. By studying the change in the concentration of methanol and ethanol, which exponentially decreased over time during catalytic oxidation with oxygen on a platinum catalyst at room temperatures, the activation energies of these reactions were found. In particular, for ethanol $E = 143$ kJ/mol.

Studies of heterogeneous oxidation of combustible gases on a long and thin wire made of metals of the platinum group, which is heated by an electric current, continue even nowadays [11]. For the occurrence of stable flameless catalytic combustion of gas when the catalyst is heated by current, the correct selection of the diameter and length of the catalyst, the range of combustible gas concentrations, the temperature and speed of the gas-air flow is necessary [12].

A classic example is the oxidation of an admixture of ammonia and hydrogen on a long platinum wire ($L/d = 1000$) with a diameter of 100 μm [13, P. 416]. In a gas-air flow with combustible gas impurities, the heating of the platinum wire (increase in temperature and electrical resistance to steady-state values) was practically carried out by heating with an electric current. Up to a certain value of the heating current, the wire behaved as inert. At different currents for different mixtures (about 0.74 ÷ 0.8 A), there was a sharp increase in the stationary temperature of the catalyst. Increasing the content of combustible gas in the mixture slightly reduces the critical value of current strength, but significantly affects the temperature level of high-temperature states and the critical value of current strength during catalytic extinction.

In this work, the non-isothermal oxidation (combustion) of small impurities of acetone and ethanol in air on a platinum wire will be considered, the critical conditions of catalytic ignition and extinction will be analyzed, and the kinetic parameters of oxidation reactions in air will be evaluated.

In view of the above, this paper assumed that the catalytic combustion of acetone and ethanol in air on a platinum wire is complete oxidation and proceeds according to the following reactions:



Thermal effect of reaction (I) $Q_1 = 1829.4$ kJ/kg, and (II) $Q_2 = 1370$ kJ/kg.

The steady-state level of high-temperature heating of the catalyst T_m during the course of one reaction in the diffusion region according to classical concepts is

determined only by the concentration of the combustible substance in the gas in which the oxidant is in excess:

$$T_m - T_g = T_Q Y_f, \quad T_Q = \frac{Q_f Le^{1-m}}{c_{pg}}, \quad (1)$$

where Q_f is the heat effect of the reaction, calculated for 1 kg of combustible gas, J/kg; Y_f is the relative mass concentration of combustible gas in the gas mixture; c_{pg} – isobaric specific heat of the gas mixture; T_g is the temperature of the gas mixture; $Le = D_f/a_g$ – Lewis number; m is an indicator of the degree of dependence of Nu on Pr and Sh on Sc . For forced convection ($0.1 < Re < 4$) $m = 0.33$.

An interesting feature of the oxidation of these gases is the difference in the Lewis number. Thus, for hydrogen $Le \approx 3$, for ammonia $Le \approx 1$, for acetone $Le = 0.586$, for ethanol $Le = 0.578$.

I. Experimental setup

For the experimental study of the oxidation of acetone and ethanol, a PMT-2 manometric thermocouple transducer was taken (Fig. 1). In it, a platinum wire with a diameter of $d = 95 \mu\text{m}$ and a length of $L = 56$ mm is used as a heater. A glass bulb with an inner diameter was cut off from the PMT-2 stand 30 mm and the upper end of the bulb. The platinum thread was bent in the form of a snake and placed in a plane perpendicular to the axis of the lamp. A tube for supplying the gas-air mixture was inserted through the hole in the lamp holder. After that, the glass bulb was glued to the base. The flask was located vertically. Thus, the incoming mixture moved relative to the thread from top to bottom (acetone and ethanol are heavier than air) and did not accumulate inside the lamp.

The gas mixture was created as follows. A small amount of liquid (acetone or ethanol) was poured into flask 8 (Fig. 1). A flow of air was fed into the liquid using a compressor. At the outlet, an air mixture with vapors of a flammable liquid was obtained. This flow could be diluted with a parallel clean air flow. The total consumption of the mixture was determined by two rotameters on the cold mixture. The temperature of the mixture before entering the chamber and inside it was determined by readings of thermocouples. To ensure the stability of the temperature on the walls of the reaction chamber, it was blown from the outside between the flask 1 and the external chamber 10 (Fig. 1) by a stream of cold air.

The main experimental dependence is the current-voltage characteristic of the wire obtained in the current stabilization mode. The platinum thread was connected to the Picotest 3510A multimeter using a three-wire circuit through the contacts of the PMT-2 lamp. In this case, the multimeter made it possible to measure the voltage and, therefore, the resistance of thread 1 (Fig. 1) together with the contacts of the lamp itself 2 without taking into account the resistance of other connecting conductors. The lamp contacts have a diameter of 1 mm. Their total resistance is $R_k = 0.105 \Omega$, which remains constant in the range of currents for research (they practically do not heat up).

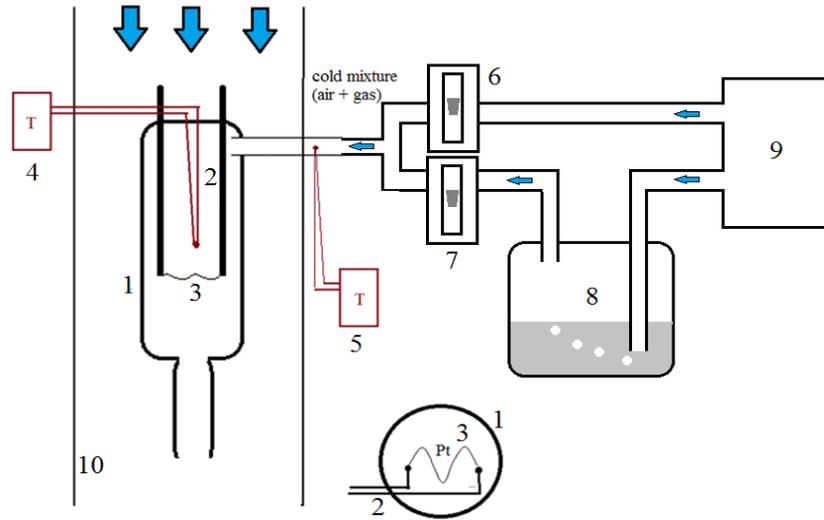


Fig. 1. Scheme of the experimental setup: 1 – PMT-2 glass bulb, 2 – connected contacts, 3 – platinum thread, 4, 5 – millivoltmeters with thermocouples; 6, 7 – rotameters of the float type, 8 – container with liquid; 9 – air compressor; 10 – external camera.

The resistance of the platinum wire is determined according to Ohm's law (without taking into account the resistance of the lamp contacts) and the average

temperature of the wire from the quadratic dependence of the resistance of the wire on temperature:

$$R_c = \frac{U}{I} - R_k, \quad \frac{R_c}{R_{c0}} = 1 + \gamma(T - T_0) - \delta(T - T_0)^2, \quad R_{c0} = \eta_0 \frac{4L}{\pi d^2}.$$

Here, $\gamma = 39.7 \cdot 10^{-4} \text{ 1/K}$, $\delta = 5.841 \cdot 10^{-7} \text{ 1/K}^2$, $\eta_0 = 9.8 \cdot 10^{-8} \text{ } \Omega \cdot \text{m}$. The resistance of a platinum wire with a length of 5.6 cm and a diameter of 95 μm at $T_0 = 273\text{K}$ is $R_0 = 0.775 \text{ } \Omega$.

The volt-ampere characteristic of a platinum wire in a gas-air mixture was recorded with a gradual increase in the strength of the flowing current in steps of 0.1 A (near critical processes in steps of 0.01 A) while establishing a stationary temperature regime of the wire for each current strength. After switching the filament to the catalytic combustion mode (catalytic ignition at 0.58-0.77 A), the current increased to 0.7-0.8 A, and then gradually decreased to 0.01 A.

When reducing the current strength in the catalytic combustion mode, there are two possible qualitatively different options depending on the concentration of the combustible gas: 1) extinction - reverse transition to the low-temperature mode at a lower value of the current strength (curves 2-3, Fig. 2) or self-extinguishing catalytic oxidation at turned off current (curve 4, Fig. 2) [9].

In fig. 2 shows the dependences of the resistance and average temperature of the platinum thread on the power of the heating current at different concentrations of

acetone and ethanol in the gas-air stream blowing the platinum thread.

Reactions (I) and (II) were used to estimate the concentration of acetone and ethanol according to formula (1). For this, the average value of the temperature difference ΔT_{exp} in high- and low-temperature regimes was determined at 3-4 values of the current strength (at the current strength of the catalytic ignition I_i and smaller than it by 0.1, 0.2 and 0.3 A). The concentration of combustible gas was calculated as $Y_f = \Delta T_{exp}/T_0$.

II. Analysis of results

Consider the physical-mathematical model of the heat-mass exchange of a long metal thread, which is heated by an electric current and the catalytic reaction of the oxidation of a small admixture of combustible gas, and is also cooled as a result of molecular-convective heat exchange with a cold gas-air mixture. The equation of unsteady thermodynamics of the metal thread of the catalyst will look like this:

$$\begin{aligned} \frac{V_c}{S_c} c_c \rho_c \frac{dT}{dt} &= q_{eff}, \quad q_{eff} = q_{ch} + q_j - q_g, \quad T(t=0) = T_b \\ q_{ch} &= Q_f \frac{k \rho_{gs} Y_f}{1 + Se}, \quad k = k_0 \exp\left(-\frac{E}{RT}\right), \quad Se = \frac{k}{\beta}, \quad q_g = \alpha(T - T_g), \quad q_j = \frac{I^2 R_c}{\pi d L}, \\ \alpha &= \beta c_p \rho_g Le^{-1+m}, \quad \beta = \frac{D_f Sh}{d}, \quad R_c = \eta \frac{4L}{\pi d^2}, \quad \eta = \eta_0 (1 + \gamma(T - T_0) - \delta(T - T_0)^2), \end{aligned} \quad (2)$$

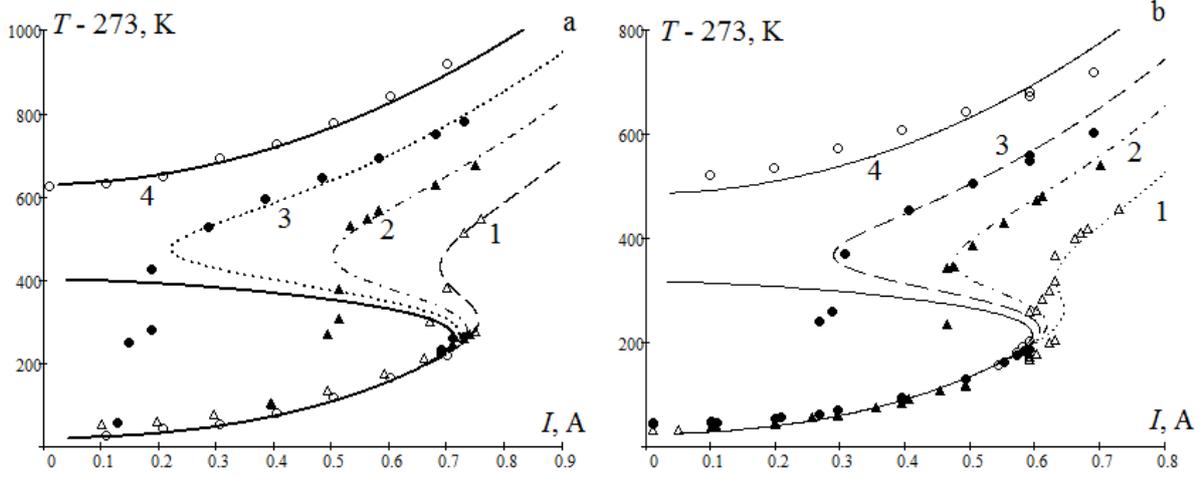


Fig. 2. Dependence of the temperature of a platinum thread (diameter 95 μm) on the strength of the heating current during the catalytic oxidation on it of a) acetone or b) ethanol in a cold gas-air mixture ($T_g = 296\text{ K}$) at different concentrations of Y_f :

- a) $\Delta - Y_{f1} = 1.41\%$; $\blacktriangle - Y_{f2} = 2.17\%$; $\bullet - Y_{f3} = 2.83\%$; $\circ - Y_{f4} = 3.53\%$;
 b) $\Delta - Y_{f1} = 0.83\%$; $\blacktriangle - Y_{f2} = 1.56\%$; $\bullet - Y_{f3} = 2.12\%$; $\circ - Y_{f4} = 2.91\%$.
 Curves 1-4 are theoretical dependences (3).

where V_c is the volume of the catalyst, S_c is the lateral surface of the catalyst, c_c is the specific heat capacity of the catalyst, $J/(\text{kg}\cdot\text{K})$; ρ_c is the density of the catalyst, kg/m^3 ; q_{eff} – effective power density of heat release, W/m^2 ; q_j is the heat released every second when an electric current passes through the cylinder catalyst, calculated per unit of side surface; R_c is the electrical resistance of the wire, Ω .

Suitable lamp contacts are 10 times thicker than a platinum filament and the ratio of the length of the filament to its diameter is almost 600. Therefore, heat dissipation through them is neglected. Considering the fact that the diameter of the platinum wire is less than 100 μm , heat exchange by radiation is also neglected.

The condition for the stationarity of the catalyst temperature $q_{eff} = 0$ is presented in the form of the dependence of the square of the current strength on the stationary temperature at a constant concentration of combustible gas in the air:

$$I = I_0 \sqrt{\frac{T - T_g}{T_0} - \frac{Y_f}{1 + Se} \frac{T_Q k_0}{T_0 \beta} \exp\left(-\frac{E}{RT}\right)}, \quad (3)$$

$$I_0 = \sqrt{\frac{\pi^2 d^2 \lambda_g Nu T_0}{4\eta}}, \quad T_Q = \frac{Q_f Le^{1-m}}{c_{pg}}.$$

The value of I_0 is a weakly decreasing function of temperature. In our case, it lies in the interval from 0.7 to 1.0 A.

Dependence (3) describes the experimental low- and high-temperature steady states. In fig. 2 presents the calculated dependence of the current strength on the steady-state temperature with the parameters of the activation energy and the pre-exponential factor found below. The maximum on this dependence determines the catalytic self-ignition of the combustible gas, and the minimum - catalytic extinction.

The following parameters were used for the

calculations: acetone: $Q_f = 31.5\text{ MJ}/\text{kg}$, $E = 84\text{ kJ}/\text{mol}$, $k_0 = 1.5 \cdot 10^6\text{ 1}/\text{c}$, $D_{j0} = 0.109 \cdot 10^{-4}\text{ m}^2/\text{s}$, $Le = 0.586$, $m = 0$, $n = 1.82$. Ethanol: $Q_f = 29.8\text{ MJ}/\text{kg}$, $E = 92\text{ kJ}/\text{mol}$, $k_0 = 4 \cdot 10^7\text{ 1}/\text{c}$, $D_{j0} = 0.10 \cdot 10^{-4}\text{ m}^2/\text{s}$, $Le = 0.578$. Other parameters: $\rho_{g0} = 1.293\text{ kg}/\text{m}^3$, $c_{g0} = 1005\text{ J}/(\text{kg}\cdot\text{K})$.

The volumetric flow rate of the gas mixture entering the bulb of lamp 1 (Fig. 1) with a thread was 17-23 cm^3/s . This corresponds to a laminar flow speed inside the bulb of 3 cm/s (Reynolds number for the lamp bulb is 58, and for the filament is 0.18). So, in this case, the influence of forced and natural convection can be neglected ($m = 0$). The Sherwood number Sh for a thin long cylinder ranges from 0.45-0.6 [14, P. 325; 13] The choice of the Sh value was determined by matching the inert analytical and experimental $T(I)$ dependences, which is actually determined by the low-temperature branch of the $T(I)$ dependence, on which the chemical reaction practically does not proceed. Thus, with the catalytic oxidation of acetone $Sh = 0.55$, ethanol $Sh = 0.45$. In the catalytic combustion mode, the temperature inside the bulb (thermocouple readings above the platinum thread) increases by 30-40 K, which indicates that natural convection prevails over forced convection on the bulb scale.

Let's apply the extremum condition $\partial I / \partial T = 0$ to dependence (3). As a result, together with (3), we will obtain a system of equations for determining the critical conditions of catalytic self-ignition (i) and extinction (e):

$$\begin{cases} I_{i,e} = I_0 \sqrt{\frac{T_{i,e} - T_g}{T_0} - \frac{RT_{i,e}^2}{ET_0} (1 + Se_{i,e})}, & (4a) \\ Y_f = \frac{RT_{i,e}^2 (1 + Se_{i,e})^2}{ET_Q Se_{i,e}}. & (4b) \end{cases}$$

In fig. 3 shows the solution of system (4). The catalyst temperature $T_{i,e}$ is used as a parameter. The position of dependencies (4) in Fig. 3 depends on the activation energy E and the pre-exponential factor k_0 . The slope of

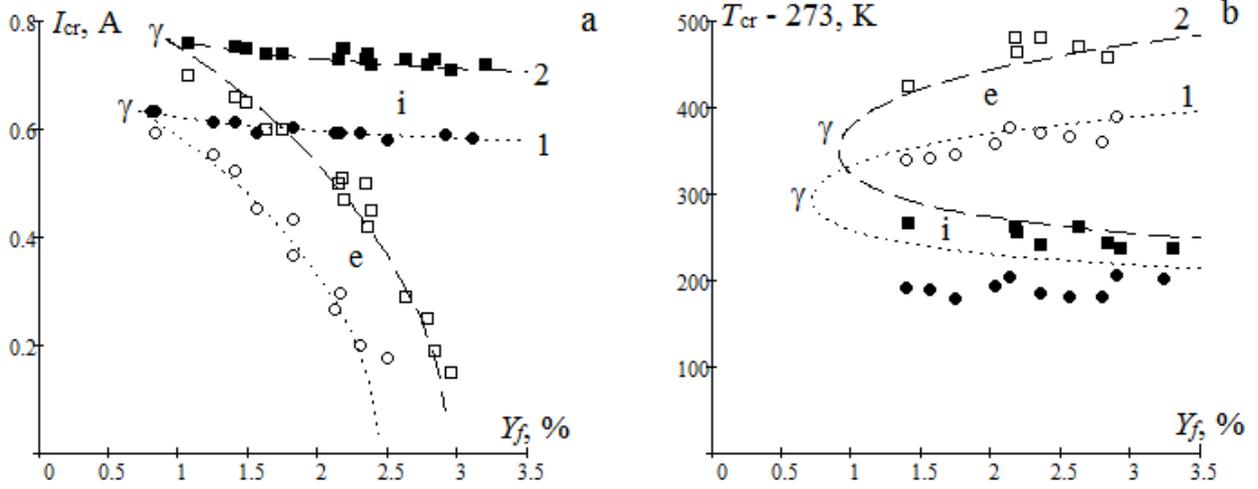


Fig. 3. Dependence of the critical value of a) the power of the heating current (self-ignition and extinction of the catalytic oxidation reaction of 1) ethanol (○, ●) and 2) acetone (□, ■) on a platinum wire with a diameter of 95 μm and b) the temperature of the wire on the concentration of combustible gas in air at room temperature $T_g = 296$ K. Lines are dependences (4).

the extinction curve is significant compared to the self-ignition curve. It is at this stage that it is already possible to find the value of the activation energy and the pre-exponential factor for each of the reactions, which would satisfactorily describe the obtained experimental data. However, let's analyze this dependence.

At the degeneracy points (point γ), the Semenov number $Se_\gamma = 0.75-0.80$. At the points of catalytic self-ignition at a distance from the point of degeneration $Se_i < 0.1$, and at the extinction points $Se_e > 3$.

Therefore, for $Se \ll 1$, the compatible solution of equations (4) leads to

$$T_g + \left(\frac{I_i}{I_0}\right)^2 T_0 = T_i - \frac{RT_{i,e}^2}{E}, \quad (5)$$

$$\frac{Q_f L e^{1-m} Y_{fi} E}{c_p g R T_i^2} Se_i = 1$$

$$\frac{T_Q Y_{fi} E}{R T_{g*}^2} \frac{k_0 d}{D_f Sh} \exp\left(-\frac{E}{R T_{g*}}\right) = \frac{1}{e} \quad \text{or} \quad \ln\left(\frac{T_Q Y_{fi}}{T_{g*}^2}\right) = \frac{E}{R} \cdot \frac{1}{T_{g*}} - \ln\left(\frac{E k_0 d}{R D_f Sh}\right).$$

In fig. 4 presents the results of the catalytic ignition of acetone and ethanol on platinum in the form of dependence $\ln\left(\frac{T_Q Y_{fi}}{T_{g*}^2}\right)$ on $\frac{1}{T_{g*}}$. As a result, the data can be described by a linear dependence, from which the value of the activation energy for the oxidation reaction of acetone on platinum was obtained $E = 85$ kJ/mol, and for ethanol $E = 92$ kJ/mol.

For points extinction, we use the schedule in (4) $(1 + Se_e)^2 / Se_e \approx Se_e + 2$. As a result, we get:

$$T_g + \left(\frac{I_e}{I_0}\right)^2 T_0 + T_Q Y_{fe} = T_e + \frac{RT_e^2}{E}, \quad (6)$$

$$\frac{T_Q E}{R T_e^2} \frac{Y_{fe}}{Se_e + 2} = 1$$

The last expression can be used to estimate the activation energy. Let's enter the effective temperature of the environment (the temperature to which an inert conductor would heat up when an electric current is passed through it)

$$T_{g*} = T_g + \left(\frac{I}{I_0}\right)^2 T_0.$$

With catalytic ignition in our case, the current strength I_i is close to I_0 , and almost twice as much as T_g . Using the Frank-Kamenetsky schedule [13] $\exp\left(-\frac{E}{R T_i}\right) \approx \exp\left(-\frac{E}{R T_{g*}}\right) \cdot e$ and approximation $\frac{R T_i^2}{E} \approx \frac{R T_{g*}^2}{E}$ the critical condition of catalytic ignition can be rewritten as:

By connecting both solutions (6), it is not difficult to obtain the dependence

$$T_g + \left(\frac{I_e}{I_0}\right)^2 T_0 = T_e - T_Q Y_{fe} \frac{Se_e + 1}{Se_e + 2},$$

which explains the dependence in fig. 3a. Namely, that at a distance from the point of degeneration of critical conditions, the square of the current strength of the catalytic quench decreases linearly with the increase in the proportion of combustible gas in the mixture.

To find the kinetic parameters, you can also use the found parameters of the degeneracy point of critical conditions. For example, it was shown in [12] that the parameters of the degeneracy point (catalyst diameter and combustible gas concentration) can be represented by the temperature of the gas mixture in the form:

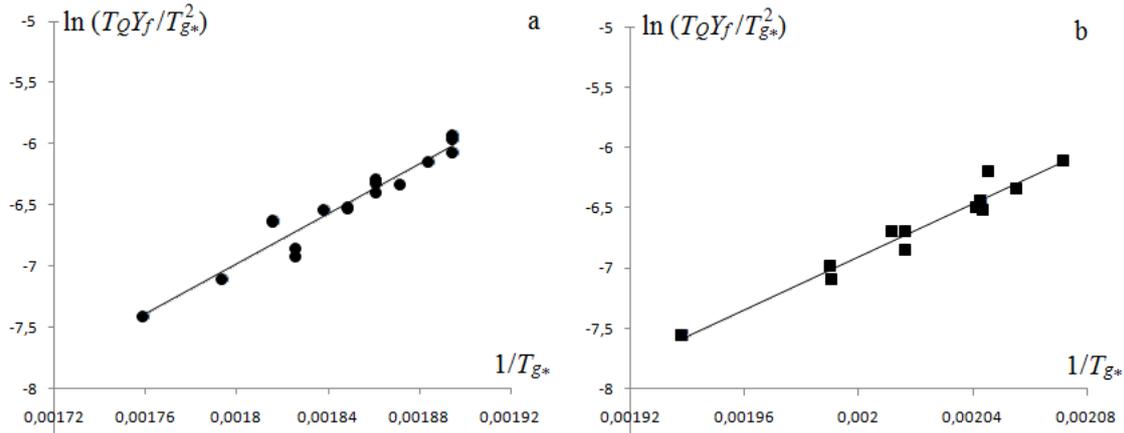


Fig. 4. Dependence $\ln\left(\frac{T_Q Y_f}{T_{g^*}^2}\right)$ on $\frac{1}{T_{g^*}}$ for the oxidation reaction of a) acetone and b) ethanol on a platinum thread.

$$d|_Y = \frac{D_f Sh}{k_0 e^2} \left(1 - 4 \frac{T_{g^*}}{T_E}\right) \exp\left(\frac{T_E}{T_{g^*}}\right), \quad Y_f|_Y = \frac{4}{(1 - 4 T_{g^*}/T_E) T_Q T_E} \frac{T_{g^*}^2}{R}, \quad T_E = \frac{E}{R}.$$

From the second equation we have

$$T_E = 4 T_{g^*} \left(1 + \frac{T_{g^*}}{T_Q Y_f}\right) \Big|_Y \quad \text{or} \quad k_0 = \frac{D_f Sh}{e^2 d} \left(1 - 4 \frac{T_{g^*}}{T_E}\right) \exp\left(\frac{T_E}{T_{g^*}}\right) \Big|_Y.$$

The temperature of the catalyst at degeneration, which needs to be known to determine I_0 and T_{g^*} , can be estimated (Fig. 3b) as the arithmetic mean between the catalytic ignition and extinction temperatures: for acetone $T_\gamma \approx 643$ K, for ethanol $T_\gamma \approx 549$ K.

So, for acetone, the degeneracy parameters $I_\gamma = 0.77$ A, $Y_{f\gamma} = 0.9$ % and, accordingly, the estimated values $E = 85.9$ kJ/mol and $k_0 = 1.4 \cdot 10^6$ m/s. For ethanol $I_\gamma = 0.64$ A, $Y_{f\gamma} = 0.8$ % and, accordingly, the estimated values $E = 91.5$ kJ/mol and $k_0 = 3.0 \cdot 10^7$ m/s. These values are close to those at which agreement of the analytical and experimental data in Fig. 3 was obtained.

Conclusions

Thus, using the assumption of complete oxidation of acetone and ethanol on platinum and the first order of the oxidation reaction, analysis of the current-voltage characteristics platinum wire in a gas mixture with small admixtures of combustible liquid vapors was performed. The temperature difference between the high and low-temperature stationary regimes of catalytic oxidation ΔT_{exp} on the wire makes it possible to estimate the concentration of the impurity in the mixture. The dependence of the critical value of the current strength of catalytic ignition and extinction on the concentration of

the impurity has a wedge-shaped shape, for the analytical description of which the values of the activation energy and the pre-exponential factor of the oxidation reaction can be estimated quite accurately. It is important that the characteristic thermal temperature complex constantly appears in analytical expressions $T_Q Y_f$, which actually is ΔT_{exp} . Therefore, for the determination of kinetic constants by this method, the real gross reaction is unimportant. As a result, it is possible to obtain visible activation energies of oxidation reactions in the given ranges of combustible gas concentrations. If we compare the oxidation of acetone and ethanol on platinum, the catalytic ignition of ethanol is easier. However, the heating of the catalyst during the oxidation of acetone is more significant.

In this thermochemical method of studying current-current characteristics, it is possible to determine the conditions of degeneration of the critical conditions of catalytic oxidation. These parameters also make it possible to evaluate the kinetic characteristics of oxidation reactions in a wide temperature range.

Chernenko A.S. – Dr. Sci., Professor;
Kalinchak V.V. – Dr. Sci., Professor;
Kopiyka A.K. – Ph.D, Ass. Prof.;
Roziznanyi M.V. – Ph.D student;
Fedorenko A.V. – Ph.D, Ass. Prof.

- [1] N. S. Marinkovic, M. Li, & R. R., Adzic, *Pt-based catalysts for electrochemical oxidation of ethanol*, Topics in Current Chemistry, 377(3), 11 (2019); <https://doi.org/10.1007/s41061-019-0236-5>.
 [2] R. Rizo, S. Pérez-Rodríguez, & G. García, *Well-defined platinum surfaces for the ethanol oxidation reaction*, ChemElectroChem, 6(18), 4725 (2019); <https://doi.org/10.1002/celec.201900600>.

- [3] Guangxing Yang, Qiao Zhang, Hao Yu, Feng Peng, *Platinum-based ternary catalysts for the electrooxidation of ethanol*, Particuology, 58, 169 (2021); <https://doi.org/10.1016/j.partic.2021.01.007>.
- [4] Yunli Ge, Kaixuan Fu, Qian Zhao, Na Ji, Chunfeng Song, Degang Ma, Qingling Liu, *Performance study of modified Pt catalysts for the complete oxidation of acetone*, Chemical Engineering Science, 206, 499(2019); <https://doi.org/10.1016/j.ces.2019.05.051>.
- [5] Chaoquan Hu, *Catalytic combustion kinetics of acetone and toluene over Cu_{0.13}Ce_{0.87}O_y catalyst*, Chemical Engineering Journal, 168, 1185 (2011); <https://doi.org/10.1016/j.cej.2011.02.006>.
- [6] Mikhail N. Lyulyukin, Alexey S. Besov, Alexander V. Vorontsov, *The Influence of Corona Electrodes Thickness on the Efficiency of Plasmachemical Oxidation of Acetone*, Plasma Chem Plasma Process, 31, 23 (2011); <https://doi.org/10.1007/s11090-010-9265-0>.
- [7] Zhiwei Wang, Sha Li, Shaohua Xie, Yuxi Liu, Hongxing Dai, Guangsheng Guo, Jiguang Deng, *Supported ultralow loading Pt catalysts with high H₂O-, CO₂-, and SO₂-resistance for acetone removal*, Applied Catalysis A: General., 579, 106 (2019); <https://doi.org/10.1016/j.apcata.2019.04.018>.
- [8] Guangxing Yang, Qiao Zhang, Hao Yua, Feng Peng, *Platinum-based ternary catalysts for the electrooxidation of ethanol*, Particuology, 58, 169 (2021); <https://doi.org/10.1016/j.partic.2021.01.007>.
- [9] S.G. Babu, P.A. Priyadarsini, R. Karvembu, Copper on boehmite: A simple, selective, efficient and reusable heterogeneous catalyst for oxidation of alcohols with periodic acid in water at room temperature, Appl. Catal. A Gen. 392 (1-2) (2011) 218–224, <https://doi.org/10.1016/j.apcata.2010.11.012>.
- [10] Francisco Jos´e Morales-Leal, Javier Rivera De la Rosa, Carlos J. Lucio-Ortiz, David A. De Haro Del R´ıo, M.A. Garza-Navarro, Wei Tian, Jose E. Herrera, *Monometallic platinum and palladium-based catalysts in the competitive oxidation of methanol over the liquid-phase methanol-ethanol mixtures*, Chemical Engineering Journal, 426, 131623 (2021); <https://doi.org/10.1016/j.cej.2021.131623>.
- [11] Mitu Maria, Razus Domnina, Oancea Dumitru, *Coupled Catalytic/Gas Phase Ignition of Propane-Oxygen-Inert Mixtures on an Isothermally Heated Platinum Filament Supported on Quartz Bar*, Revista de Chimie (Bucharest). 69(4), 870 (2018); <https://doi.org/10.37358/RC.18.4.6218>.
- [12] V.V. Kalinchak, O.S. Chernenko, Thermal physics of flameless combustion of gases (monograph) (Odesa, Astroprint, 2020); <http://dspace.onu.edu.ua:8080/handle/123456789/28625>
- [13] D. A. Frank-Kamenetskiĭ, N. Thon, Diffusion and heat exchange in chemical kinetics (Princeton University Press, Princeton, New Jersey, 1955).
- [14] John H. Lienhard IV and John H. Lienhard V, A heat transfer textbook, 3rd ed (Cambridge, MA : Phlogiston Press, 2001).

О.С. Черненко, В.В. Калінчак, О.К. Копійка, М.В. Розізнаний, А.В. Федоренко

Каталітичне окислення ацетону і етанолу на платиновому дроті

Одеський національний університет імені І.І. Мечникова, teplophys@onu.edu.ua

Отримані вольт-амперні характеристики тонкого довгого платинового дроту повітрі з малими домішками парів ацетону чи етанолу. Використовуючи квадратичну залежність опору платини від температури розраховані температурно-струмові залежності для дроту. При концентраціях парів горючого газу вище певного значення ці залежності проявляють гістерезисний характер. Використовуючи припущення про повне окислення ацетону та етанолу на платині, як каталізаторі, та перший порядок реакції окислення, виконаний аналіз температурно-струмових залежностей. Різниця температур високо та низькотемпературного стаціонарних режимів каталітичного окислення на дротині дозволяє оцінювати концентрацію домішки в суміші. В результаті побудована експериментальна залежність критичного значення сили струму каталітичного займання та погасання газової суміші на платині від концентрації домішки. При її аналітичному описі можна доволі точно оцінити видимі значення енергії активації та передекспонентного множника реакції окислення в широкому температурному діапазоні. Запропоновано метод визначення кінетичних параметрів реакції окислення по знайдених експериментально параметрам вирождення критичних умов.

Ключові слова: каталізатор, платиновий дріт, діаметр, мала домішка газу, ацетон, етанол, займання, погасання, горіння.