

Obtaining vinyl chloride by oxychlorination of ethylene under the action of hydrogen chloride in the presence of oxygen

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Abstract. In the article, the thermodynamics of the oxychlorination processes of ethylene in the presence of oxygen under the influence of hydrogen chloride were studied and the mechanism of the oxychlorination reaction was proposed. Kinetic equations describing the rate of formation of 1,2-dichloroethane and carbon dioxide were proposed based on the study of the mechanism of the process. The laws of formation of complete oxidation products of oxychlorination of ethylene with hydrogen chloride in the presence of oxygen in the presence of catalysts obtained for the oxychlorination reaction of ethylene with hydrogen chloride in the presence of oxygen were studied in a fluidized bed reactor designed for the oxychlorination reaction of ethylene in the presence of oxygen under the influence of hydrogen chloride. The temperature range is 210-240 °C, the linear velocity of gases is 5.5-7 cm/sec, and the contact time of the oxychlorination reaction of conditioned ethylene with hydrogen chloride in the presence of oxygen is 8.5-9.5 sec. The ethylene oxychlorination reactor consists of a 32.5 m column apparatus with a diameter of 3.5 m. The operating modes of the reactor designed for the oxychlorination of ethylene under the influence of hydrogen chloride in the presence of oxygen were determined, and the material and heat balance of the reactor designed to carry out the oxychlorination reaction was calculated. The purpose of the work is to study the thermodynamic and kinetic laws of the oxychlorination processes of ethylene under the influence of hydrogen chloride in the presence of oxygen and to create a technology for obtaining vinyl chloride.

1 Introduction

Production of vinyl chloride is increasing and it is one of the largest products of organic synthesis, and up to 95% of the produced vinyl chloride is used to make polyvinyl chloride. A small amount of vinyl chloride is used to obtain various vinyl copolymers. The first place in terms of production volume of polymer materials is polyethylene, followed by polyvinyl chloride, which proves its most important role in the world industrial production

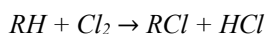
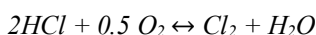
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infrastructure. Technologically, it is desirable to carry out the oxychlorination of ethylene in a liquid layer of the catalyst using concentrated oxygen as an oxidizing agent. The implementation of this is an industrial-scale process, the selectivity of the formation of ethylene chloride is significantly increased and the amount of gas emissions is reduced. Creating an industrial oxychlorination process using oxygen as an oxidant requires choosing an optimal catalyst, studying its operating conditions, and calculating and creating an industrial reactor [1,2].

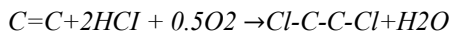
Oxychlorination of a wide range of hydrocarbons and their chlorinated derivatives has been described in the literature. Oxychlorination is carried out in solution and catalyst solution, in the presence of a heterogeneous catalyst in the gas phase [3,4,5].

According to the mechanism, all oxychlorination reactions can be divided into two large groups:

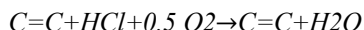
- 1) Reactions passing through intermediate oxidation of hydrogen chloride with oxygen to chlorine, which chlorinates the organic substrate;
- 2) Reactions that do not require the oxidation of hydrogen chloride to chlorine, the first group includes oxychlorination reactions that replace alkanes and chloroalkanes:



And the second is additive oxychlorination of alkanes and chloroalkanes

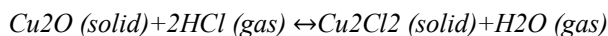
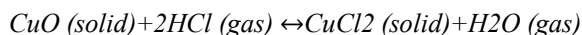


alkenes are divided into a separate group in work [6,7]:



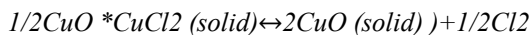
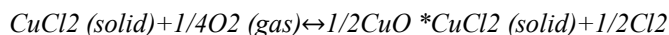
The reaction proceeds at a temperature where hydrogen chloride oxidation and alkane-substituted oxychlorination take place, but there is no chlorine in the gas phase. The most common industrial application found the process of ethylene oxychlorination to ethylene chloride due to the large scale of production of vinyl chloride and the almost complete use of hydrogen chloride produced during its production.

The thermodynamic aspects of the interaction of the catalyst with the initial results of the oxychlorination processes were considered in detail [8,9,10]. The following reactions are thermodynamically possible in the temperature range of 400 – 800 K indicated for the CuO-HCl and Cu₂O-HCl systems:



The value of the standard free energy for these reactions is in the range (-12÷28 kcal/mol); in this case, the relative equilibrium constants decrease rapidly with increasing temperature [11,12].

The results of experimental studies of copper chloride-oxygen reactions were obtained in [13,14]. The reaction is shown to proceed in two stages:



In recent years, obtaining ethylene and aromatic hydrocarbons directly from methane has been of interest to world scientists. At the same time, obtaining synthesis gas from methane and methanol and dimethyl ether, and synthesizing lower molecular weight olefins from dimethyl ether and methanol has not lost its relevance. It is known that aromatic

hydrocarbons are important in organic synthesis. A lot of research is being conducted in the world on the synthesis of aromatic hydrocarbons from propane-butane fractions and petroleum satellite gases. In general, the synthesis of substances important for the chemical industry from natural gas, a single source that can replace oil, is one of the urgent issues [15,16,17].

2 Experimental part

Oxychlorination of ethylene with oxygen under the influence of hydrogen chloride was carried out at atmospheric pressure and the study of kinetic and technological laws of oxidation processes. During the experiment, the temperature varied between 205÷245 °C. In the process of oxychlorination of ethylene in the presence of oxygen under the influence of hydrogen chloride, the ratio of the initial reaction substances is 1.02÷1.04:2.00:0.60÷0.65. Gas consumption ~ 60-120 nl/hour. The contact time of the oxychlorination reaction of ethylene with hydrogen chloride in the presence of oxygen was determined based on the actual conditions of the process:

$$\tau = V_{cat} / Q$$

here: V_{cat} - volume of the selected catalyst in the reactor designed to carry out the reaction of oxychlorination of ethylene with hydrogen chloride in the presence of oxygen;

Q - Gas flow rate under normal conditions;

When the ratio of reactants changed, the total consumption of gas remained unchanged.

The laws of formation of complete oxidation products of oxychlorination of ethylene with hydrogen chloride in the presence of oxygen in the presence of catalysts selected for the oxychlorination reaction of ethylene with hydrogen chloride in the presence of oxygen were studied in a fluidized bed reactor designed for the oxychlorination reaction of ethylene in the presence of oxygen under the influence of hydrogen chloride. The temperature range is 210-240 °C, the linear velocity of gases is 5.5-7 cm/sec, and the contact time of the oxychlorination reaction of conditional ethylene with hydrogen chloride in the presence of oxygen is 8.5-9.5 sec.

Below are some properties of the catalysts selected for the oxychlorination reaction of ethylene with hydrogen chloride in the presence of oxygen.

Table 1. Some properties of selected catalysts for the oxychlorination reaction of ethylene with hydrogen chloride in the presence of oxygen

	<i>KCl*ZnCl₂*MnCl₂*CuCl₂</i>	<i>KCl*ZnCl₂*CuCl₂</i>	<i>KCl*MnCl₂*CuCl₂</i>
Copper content, %, mass	4.2	5.2	4.8
Specific surface area, m ² /g	120	125	115
The size of the holes	0.36	0.32	0.24
Average radius, pore, nm	4.6	5.25	5.4

To carry out the oxychlorination reaction of all ethylene with hydrogen chloride in the presence of oxygen, catalysts with a particle size of 40-60 microns were selected. The effect of carbon oxides on the selectivity of simm-dichloroethane (1,2-dichloroethane) formation was studied in a reactor with a diameter of 42 mm designed for the oxychlorination reaction of ethylene with hydrogen chloride in the presence of oxygen. The volume of the selected catalyst for the oxychlorination reaction of ethylene with hydrogen chloride in the presence of oxygen was 840 ml. For the study, *KCl*ZnCl₂*CuCl₂*, a catalyst selected for the

oxychlorination reaction of ethylene with hydrogen chloride in the presence of oxygen, was used.

3 Results and discussion

3.1 Thermodynamics of oxychlorination processes of ethylene under the action of hydrogen chloride in the presence of oxygen

Thermodynamic parameters of oxychlorination processes of aliphatic hydrocarbons, and ethylene under the influence of hydrogen chloride in the presence of oxygen are mainly determined by the Dickon reaction. For the K_r value of the conversion rate of hydrogen chloride and H_2O to decrease, the temperature must increase. In the temperature range of 200-2000 °C, the following expression of the temperature dependence of K_r applies:

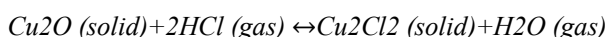
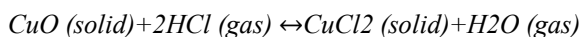
$$\lg Kr = 5881.7/T - 0.93035 \lg T + 1.3704 \cdot 10^{-4} - 1.758 \cdot 10^{-3} T^2 - 4.1744$$

or in simplified form:

$$\lg Kr = 6104/T - 7.0994$$

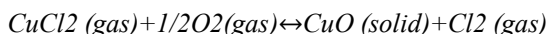
During chlorination, due to the consumption of chlorine, the equilibrium of the reaction shifts to the right, and a complete conversion of hydrogen chloride occurs [18,19].

The oxychlorination reaction of ethylene in the presence of oxygen was carried out by Allen and Clark [20,21], and they examined in detail the thermodynamic aspects of the interaction of the catalyst selected for this with the initial results of the oxychlorination processes of ethylene under the influence of hydrogen chloride. In the temperature range of 400 – 800 K indicated for the CuO-HCl and Cu₂O-HCl systems, the following reactions can occur thermodynamically:

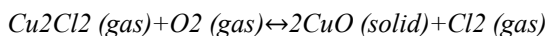


The value of the standard energy for these reactions is in the range (-12 -28 kcal/mol); in this case, the temperature should increase to decrease the relative equilibrium constants [22,23]. ÷

During the study of reactions of copper-chlorinated compounds with oxygen, it was shown that the processes of gaseous copper chlorides' interaction with oxygen are much easier than the reactions involving rent [24,25,26,27,28]. For example, the conditions of the low-temperature oxychlorination process of ethylene (T=220 °C).

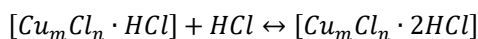
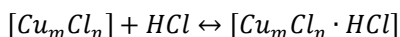


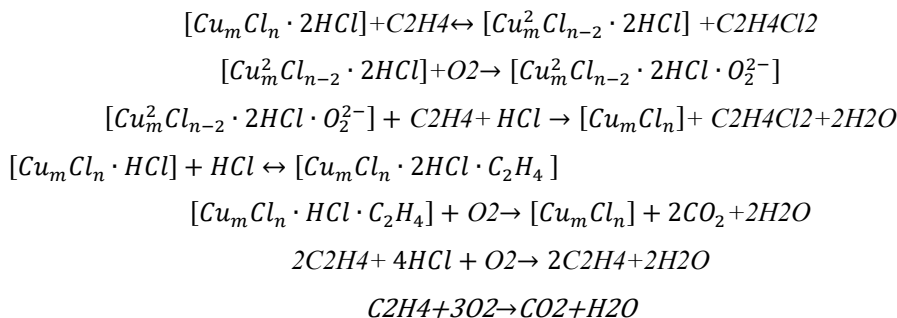
the value of the standard free energy for the reaction is -18.5 kcal/mol,



and for the reaction is equal to -74.1 kcal/mol.

The oxychlorination of ethylene was studied in the temperature range of 250-340 °C in the CuCl₂-KCl aluminosilicate (or silica gel) catalyst selected for the oxychlorination reaction of ethylene with hydrogen chloride in the presence of oxygen, the following reaction mechanism was proposed:





Kinetic equations describing the rate of formation of simm-dichloroethane (1,2-dichloroethane) (W_a) and carbon dioxide (W_b) form b:

$$\begin{aligned}
 W_A &= 2 \frac{K_1^I \cdot K_1^{II} \cdot K_2 \cdot P_{HCl}^2 \cdot P_{C_2H_4}}{1 + K_1^I \cdot P_{HCl} \cdot \left[1 + K_5 \cdot P_{C_2H_4} + K_1^{II} \left(1 + \frac{K_2 \cdot P_{C_2H_4}}{K_3 \cdot P_{O_2}} \right) \right]} \\
 W_b &= \frac{K_1^I \cdot K_5 \cdot K_6 \cdot P_{HCl}^2 \cdot P_{C_2H_4}}{1 + K_1^I \cdot P_{HCl} \cdot \left[1 + K_5 \cdot P_{C_2H_4} + K_1^{II} \cdot P_{HCl} \cdot \left(1 + \frac{K_2 \cdot P_{C_2H_4}}{K_3 \cdot P_{O_2}} \right) \right]}
 \end{aligned}$$

If we continue this,

$$K_1^{II} \cdot P_{HCl} \gg 1 + K_5 \cdot P_{C_2H_4}$$

The following equations will have the following form.

$$\begin{aligned}
 W_A &= 2 \frac{K_1 \cdot K_2 \cdot P_{HCl}^2 \cdot P_{C_2H_4}}{1 + K_1 \cdot P_{HCl}^2 \cdot \left(1 + \frac{K_2 \cdot P_{C_2H_4}}{K_3 \cdot P_{O_2}} \right)}, \\
 W_b &= \frac{K_1^I \cdot K_5 \cdot K_6 \cdot P_{HCl} \cdot P_{C_2H_4} \cdot P_{O_2}}{1 + K_1 \cdot P_{HCl}^2 \cdot \left(1 + \frac{K_2 \cdot P_{C_2H_4}}{K_3 \cdot P_{O_2}} \right)} \\
 & \text{Here, } K_1 = K_1^I \cdot K_1^{II}
 \end{aligned}$$

4 Principle technological scheme for oxychlorination of ethylene

The principle technological scheme of oxychlorination of ethylene using oxygen is given based on experiments and calculations. The diagram shows the transition from the state of pyrolysis of ethylene chloride to the oxythitic chlorination of hydrogen chloride. This means that hydrogen chloride produced during pyrolysis is first introduced into the reactor for hydrogenation, where acetylene is hydrogenated to form ethylene. The process takes place at 130-180 °C in the extruded $CuCl_2 \cdot ZnCl_2 \cdot MnCl_2 \cdot KCl / Al_2O_3$ catalyst layer. Residual acetylene in HCl did not exceed 0.02-0.04%. Hydrogen chloride leaves the reactor and goes to the mixer at a temperature of 150-180 °C, where it is mixed with concentrated oxygen. The system can also be supplied with hydrogen chloride produced elsewhere, as long as it is of the required quality. Ethylene is also introduced into the reactor as a mixture under 0.6 MPa, and chlorinating released vapour-gas mixtures heated to 180 °C are introduced under a pressure of 0.6 MPa.

The ethylene oxidizing chlorination reactor consists of a 32.5 m diameter 3.5 m column apparatus. The recirculating separated steam-gas mixture and ethylene are introduced into

the lower part of the reactor, equipped with spherical distribution downward pipes, from under the plate. Chlorinated hydrogen and oxygen enter the reactor through the mixing section, and the downward pipe is also introduced into the distribution plate through the outlet. Nominal consumption of reagents: hydrogen chloride 6200 nm³/hour, ethylene 3200 nm³/hour; oxygen 1600 nm³/h; and circulating gas is 8000-10000 nm³/hour.

The reaction gases pass upward through the catalyst layer at a speed of 0.25-0.35m/sec. This improves the interaction between the catalyst and the reaction gases. According to this, exothermic process in the reactor, steam condensate under a pressure of 0.8-1.2 MPa takes away heat at a level that accounts for 10% of the reaction due to evaporation. After that, the gas mixture is cleaned in a three-stage cyclone placed in the upper part of the reactor, and the catalyst removed in the cyclones is returned to the burnt layer. To form a well-burnt layer, the particle size should be less than 25-35% by mass. This can be achieved by impacting large particles during the work process. In good cyclones, particles larger than 10 µm are returned to the water. For normal heat supply, the level of the pseudo-sintered layer in the reactor catalyst should be the same as the level of the catalyst in the filled coil. Ethylene chloride - passes from the condenser to the gas mixture and liquid separator. The gas consists of carbon oxide and dioxide, oxygen, ethylene nitrogen and ethylene chloride, and vaporized water. The liquid phase is separated into two layers - upper-water, lower-ethylene chloride. The steam-gas mixtures coming out of the separation volume at a temperature of 20 °C and below 0.23-0.33MPa go to the compressor, the resulting steam-gas mixtures are compressed to 0.6MPa for circulation and sent to the reactor for oxychlorination, premixed with ethylene. The consumption of circulating gas is equal to 8-12 thousand nm³/h, and a smaller part of separated vapor-gas mixtures (130-150 nm³/h) is directed to burning after condensation in the refrigerator. Ethylene chloride in the separated steam-gas mixtures is directed to the vessel after condensing in the refrigerator. The average composition of separated vapor-gas mixtures, which are discharged from the system: CO₂-55-65%, N₂-25-30%, C₂H₄-3-5%, CO-1-3%, O₂-1%. The amount and composition of CO and CO₂ in the released vapour-gas mixture and the total consumption of the released vapour-gas mixtures depend on the conditions of the process and the type of catalyst used. From the ethylene chloride-crude separation tank, the water is directed to a mixing tank. A 40% alkali solution in the reaction product is added to decompose the chlorine. The heating of the water layer from the separator is directed to the column. Ethylene chloride, washed from the body with alkali, is directed to a container for washing with water. After that, it goes to the component separation system.

5 Calculation of operating modes of the reactor designed for oxychlorination of ethylene under the influence of hydrogen chloride in the presence of oxygen

Calculation based on the following conditions done: the selected catalyst for the oxychlorination reaction of ethylene with hydrogen chloride in the presence of oxygen is KCl*ZnCl₂*CuCl₂, 55 tons were loaded into the reactor designed for the oxychlorination reaction of ethylene with hydrogen chloride in the presence of oxygen.

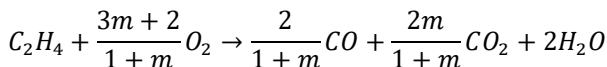
The selectivity of the formation of 1,2-dichloroethane is 0.97.

C₂H₄:HCl: O₂= 1.01: 2: 0.6 ratio:

The conversion of hydrogen chloride and ethylene is 0.993; 0.96.

When calculating the operating modes of the reactor designed for the oxychlorination of ethylene under the influence of hydrogen chloride in the presence of oxygen, the kinetic equations of the formation rate of 1,2-dichloroethane $W=kC_{C_2H_4}$, carbon monoxide, carbon dioxide, and the equations of the relationship between the reaction reagents and the reaction products were used, taking into account the selectivity.

The gross equation for combustion reactions is:



here, $\frac{3m+2}{1+m} = v_k$ - stoichiometric coefficient of oxygen consumption in combustion reactions.

The equations for the components are written in the following form:

The conversion rate of hydrogen chloride, $X_{HCl} = \frac{N_{HCl}^0 - N_{HCl}}{N_{HCl}^0}$

$$N_{C_2H_4} = N_{C_2H_4}^0 - N_{DXE} \left(1 + \frac{1 - S_e}{S_e} \right)$$

Here, $N_{C_2H_4}$ is the flow of unreacted ethylene

S_e – selektivligi

$$N_{O_2} = N_{O_2}^0 - N_{DXE} \left(0.5 + v_k \frac{1 - S_e}{S_e} \right)$$

Here, N_{O_2} is the flow of unreacted oxygen

$$N_{HCl} = N_{HCl}^0 - 2N_{DXE}$$

$$N_{CO+CO_2} = 2 \frac{1 - S_e}{S_e} N_{DXE}$$

Here is the combustion flow of the product N_{CO+CO_2}

$$N_{H_2O} = N_{DXE} + 2 \frac{1 - S_e}{S_e} N_{DXE}$$

Here is the flow of water, mol N_{H_2O}

$$\sum N_i = N_{C_2H_4}^0 (1 + \alpha + \beta + \gamma) - \left[1.5 - (3 - v_k) \frac{1 - S_e}{S_e} \right] 0.5 \alpha N_{C_2H_4}^0 Y_{HCl} \dots$$

Here Hydrogen chloride, O2 inert stream $C_2H_4 \alpha, \beta, \gamma$ – oqim nisbati, mol

$$\alpha = \frac{N_{HCl}^0}{N_{C_2H_4}^0}, \dots \beta = \frac{N_{O_2}^0}{N_{C_2H_4}^0}; \dots \gamma = \frac{N_{in}^0}{N_{C_2H_4}^0}$$

N_{in}^0 – a molten stream of inerts entering a reactor designed to carry out the oxychlorination reaction of ethylene with hydrogen chloride in the presence of oxygen.

The partial pressure of the reacting substances is expressed as follows.

$$P_{C_2H_4} = \frac{N_{C_2H_4}}{\sum N} P; \dots P_{HCl} = \frac{N_{HCl}}{\sum N} P; \dots P_{O_2} = \frac{N_{O_2}}{\sum N} P$$

Here, the pressure of the reactor designed to carry out the oxychlorination reaction of R-ethylene with hydrogen chloride in the presence of oxygen, atm

The degree of conversion of hydrogen chloride and the contact time of the reaction of oxychlorination of ethylene with hydrogen chloride in the presence of oxygen under normal conditions is expressed by the equation:

$$W = \frac{d(N_{DXE} 22.4)}{dG_{kat}} = \frac{0.5 N_{HCl}^0 22.4 \cdot 4.3600 dX_{HCl}}{\gamma_{nas} \cdot 22.4 (1 + \alpha + \beta + \gamma) N_{C_2H_4}^0 d\tau}$$

Here is the mass of the catalyst selected for the oxychlorination reaction of γ_{Nas} -ethylene with hydrogen chloride in the presence of oxygen. The contact time of the oxychlorination reaction of t-current ethylene with hydrogen chloride in the presence of oxygen, sec, so:

$$W = \frac{dX_{HCl}}{d\tau} = \frac{\gamma_{nas}}{3600} \cdot \frac{2}{\alpha} (1 + \alpha + \beta + \gamma)W$$

In the reactor used in the industry for the oxychlorination reaction of ethylene with hydrogen chloride in the presence of oxygen, the working speed of the gas is much higher than the initial speed of liquefaction, which ensures intensive mixing of particles with increasing hardness and isothermal layer. The directed flow of the diluent and the short residence time in the fluidized bed make it possible to adopt an ideal gas and ideal heat exchange model.

The calculations were carried out proportionally to the two-phase model, in which part of the gas approaches the initial velocity of liquefaction (dense phase). The remaining gas rises through the layer in the form of spheres (bubble phase). The reaction phase is dense and mass is transferred between the phases, the intensity of which determines the final degree of conversion.

Equations of the two-phase model for hydrogen chloride:

$$\frac{dy}{d\tau} = \frac{\beta}{g}(x - y)$$

$$\frac{dx}{d\tau} = \frac{\beta}{1 - g}(x - y) + \frac{W_i}{1 - q}$$

Initially: =0 at $x=y=0, \tau$

$$\tau = \tau_k \tau = \tau_k x_k = qx + (1 - q)y$$

τ - current time, sec; the contact time of the reaction of oxychlorination of ethylene with hydrogen chloride in the presence of oxygen varies from zero to zero τ_k

q - the amount of gas passed from the dense phase.

β - coefficient of transferred mass, sec-1.

X_k is the final conversion of hydrogen chloride.

Heat balance equation of the process

$$0.5N_{HCl}^0 X_{HCl} \left\{ (-\Delta H_1) + \frac{1 - S_e}{S_e} [(-\Delta H_2) + m(-\Delta H_3)] \right\} = kF(T_p - T_x) + N_{\Sigma}^0 \int_{T_0}^{T_p} c_{p_i}(T) dt$$

Here:

$(-\Delta H_1) = 56 * 10^3 \text{kcal/kmol}$ Thermal effect of 1,2-dichloroethane formation reactions

$(-\Delta H_2) = 167 * 10^3 \text{kcal/kmol}$ - thermal effect of the gas formation reaction;

$(-\Delta H_3) = 330 * 10^3 \text{kcal/kmol}$ - heat effect of carbon dioxide formation reaction;

K is the coefficient of heat transfer from the liquid layer to the cold surface, kcal/m hour $^{\circ}\text{C}$;

T_p is the temperature $^{\circ}\text{C}$ designed to carry out the oxychlorination reaction of ethylene with hydrogen chloride in the presence of oxygen;

T_x - cooling water temperature $^{\circ}\text{C}$;

F - the surface of the heat sink, m^2 ;

N_{Σ}^0 - the total flow at the reactor inlet, kmol/h, designed to carry out the reaction of oxychlorination of ethylene with hydrogen chloride in the presence of oxygen;

$C_{ii}(T)$ - heat capacity of the reacting substance, kcal/kmol $^{\circ}\text{C}$;

a_i is the volume fraction of ethylene oxychlorination reagents at the reactor inlet;

T_0 is the temperature of the reactor designed for oxychlorination of ethylene, °C.

6 Material and heat balance of the reactor designed for the oxychlorination reaction of ethylene with hydrogen chloride in the presence of oxygen

The material and heat balances of the reactor designed for the oxychlorination reaction of ethylene in the presence of oxygen with hydrogen chloride were calculated by changing the load on hydrogen chloride from 3500 to 9000 nm^3/s . The results of the calculation of heat balances are presented in Tables 2 and 3.

As can be seen in the tables, two lines correspond to each mode. The upper row contains the calculated data at the entrance to the reactor designed for the oxychlorination reaction of ethylene with hydrogen chloride in the presence of oxygen, the operating speed was determined in the pressure mode $T_p=220$ °C. The next row contains the data calculated according to the conditions at the outlet of the reactor designed for the oxychlorination reaction of ethylene with hydrogen chloride in the presence of oxygen.

Table 2. Indicators of the ethylene oxychlorination process. Used oxygen and gas processing. $\epsilon = 0.97$, $\epsilon = 0.99S_{\epsilon}X_{HCl}$

W_{HCl}^0	$W_{C_2H_4}^0$	$W_{O_2}^0$	W_{pu}	W_E	P	ω	$C_{C_2H_4}$	C_{O_2}	C_{CO_2}	ΔT	$X_{C_2H_4}$	τ_k
nm ³ /s					atm	m/sec	Volume fraction			°C		Sec
3500	1770	1050	6000	12320	4.0	0.23	0.15	0.09	0.30	18.64	0.90	16.07
			9725	9725	3.0	0.24	0.02	0.02	0.39			
			8000	14320	4.0	0.26	0.14	0.09	0.35	15.5	0.88	13.83
			11729	11729	3.0	0.29	0.02	0.02	0.43			
			10000	16320	4.0	0.29	0.12	0.08	0.38	18.36	0.86	12,13
			13730	13730	3.0	0.34	0.03	0.02	0.21			
6700	3390	2010	6000	18100	4.5	0.29	0.19	0.12	0.21	36.07	0.93	10.94
			13137	13137	3.5	0.28	0.02	0.02	0.29			
			8000	20100	4.8	0.31	0.18	0.11	0.25	35.94	0.92	9.85
			15137	15137	3.8	0.29	0.02	0.02	0.34			
			10000	22100	5.1	0.32	0.16	0.10	0.28	35.79	0.91	8.96
			17137	17137	4.1	0.33	0.02	0.02	0.37			
9000	4545	2700	6000	22245	5.0	0.33	0.21	0.13	0.17	48.6	0.94	8.9
			15577	15577	4.0	0.29	0.02	0.02	0.26			
			8000	24245	5.5	0.32	0.19	0.12	0.21	48,46	0.93	8.16
			17578	17578	4.5	0.29	0.02	0.02	0.29			

Table 3. The calculation of heat balances

W_{HCl}^0	W_{pu}	p	C_p	μ	λ	Re	Ar	Heat transfer coefficients were calculated by equations			
nm ³ /s	nm ³ /s	Kg/m ³	Kcal/s	Kg/m·s	kcal/m·s·°C			4.26	4.27	4.28	4.29
3500	6000	3.3	0.28	0.076	0.027	2.00	39.3	712	666	853	893
		3.2	0.32	0.075	0.029	2.02	38.1	723	699	920	963
	8000	3.4	0.29	0.076	0.028	2.33	39.3	739	669	861	902
		3.1	0.32	0.076	0.029	2.33	35.9	757	701	913	956
	10000	3.4	0.29	0.076	0.028	2.66	39.3	762	671	865	905
		3.0	0.32	0.077	0.029	2.64	34.4	787	702	909	951
6700	6000	3, 8	0.28	0.075	0.027	2.93	44.2	754	658	856	898
		4.1	0.33	0.073	0.029	3.03	50.6	744	695	960	1008

	8000	4.0	0.28	0.075	0.027	3.26	46.7	764	662	853	915
		4.2	0.32	0.074	0.029	3.33	51.1	758	696	965	1013
	1000	4.8	0.28	0.075	0.027	4.04	56.7	768	662	905	951
		5.0	0.32	0.0745	0.0296	4.073	59.72	765	697	998	1049
9000	6000	4.18	0.278	0.0751	0.0267	3.6	49.22	771	656	868	912
		4.78	0.326	0.0721	0.0291	3.75	61.00	748	691	987	1039
	8000	4.62	0.28	0.0753	0.027	3.93	54.02	771	660	893	938
		5.21	0.325	0.0729	0.0294	4.06	65.04	750	695	1007	1060

7 Conclusion

1. The thermodynamics of oxychlorination processes of ethylene under the influence of hydrogen chloride in the presence of oxygen were studied.
2. The material and heat balance of the reactor designed for the ethylene oxychlorination reaction was calculated.

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