## THERMAL DECOMPOSITION OF AMMONIUM NICOTINATE

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The method for the isolation of free pyridinecarboxylic acids by the thermal decomposition of their ammonium salts has been known for a long time, and for ammonium nicotinate (I) is described in [1].

The thermal decomposition of I was studied at 123, 136, and 150°C. At all these temperatures, ammonia is liberated at a constant rate during almost the whole course of the reaction. As a result of thermal decomposition, nicotinic acid (II) and ammonia (III) are obtained. Practically complete decomposition of I was observed at 150°C in the course of 1 h.

To intensify the process, in the present work we decomposed crystalline ammonium nitotinate in a heat-carrier flow at a temperature close to those used in [1].

The diagram of the installation for studying the hydrodynamics of the layer and thermal decomposition of ammonium nitocinate is shown in Fig. 1.

In apparatus 1, a layer of particles (crystals) of I is loaded from feed bin 3 onto an exchangeable perforated distribution grid 2 to a given height. The air, fed through rotameter 8 heats up in electric heater 9, passes through the grid and sets the layer of the material into motion. The resistance of the grid and the layer is measured by an inclined micromanometer MAN 10, and the temperature under the grid, in the layer, and at the outlet is measured by chromel-copel thermocouples, whose emf is recorded by KSP-4 potentiometer 11 with an accuracy within  $\pm 0.5\%$ .

In the experiment, perforated grids with a clear opening of 1.6, 4, and 6.6% were used. Compound III formed during the decomposition of I is carried away with the heat carrier, passes through bubbler 6, and is trapped by sulfuric acid in bubbling vessel 7. At the end of the process, the solution was titrated, and the product remaining in the apparatus and entering collector 5 through cyclone 4 was analyzed for the content of II.

The apparatus was made of glass, so that the visual observations required to study the hydrodynamics of the process were possible.

For a preliminary calculation of the construction parameters of the apparatus, we must determine the dependence of the pressure drop on the stream velocity of the heat carrier and the height of the layer.

It is known that the homogeneity of the mobile layer of the particles increases with decrease in their size, but below a certain limit the forces of interaction between the particles increase, which leads to agglomeration and channel formation. We studied the principal characteristics of the mobile layer of I. A microstructural analysis of the semidispersed layer of I showed that the layer consists mainly of aggregates of particles of size 50 to 150  $\mu$ m (mean size 100  $\mu$ m). After the thermal decomposition of I, the large aggregates break down, and the mean particle size is 30  $\mu$ m.

The bulk density of dry I ( $\gamma_{bulk}$ ) is equal to 600 kg/m<sup>3</sup>, and the specific weight ( $\gamma_{0}$ ) is 1770 kg/m<sup>3</sup>.

The porosity of the mobile layer ( $\epsilon_{lr}$ ) was determined from the formula

$$\varepsilon_{\rm lr} = 1 - \frac{\gamma \, \rm bulk}{\gamma_0}. \tag{1}$$

The stream velocity of the heat carrier required to create a mobile layer was determined indirectly by measuring the sheet resistance:

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Fig. 1. Installation diagram for studying the hydrodynamics and thermal decomposition of ammonium nicotinate in mobile layer. Explanations in text.



Fig. 2. Dependence of resistance of distribution grid (in mm Hg) on stream velocity of air (in m/sec) at different free openings. 1) 1.6%; 2) 4.0%; 3) 6.6%.

Fig. 3. Dependence of pressure drop of layer (in mm Hg) on the air stream velocity (in m/sec) at different layer heights. Free opening of grid 6.6%. 1) 100 mm; 2) 85 mm; 3) 60 mm.

$$P_{\text{total}} = \Delta P_{\text{grid}} + \Delta P_{1r}, \qquad (2)$$

and hence,  $\Delta P_{1r}$  can be easily determined by determining  $\Delta P_{total}$  and  $\Delta P_{grid}$ .

It is known [2] that when a layer of a dispersed material is blown through, the sheet resistance increases with increase in the rate of blowing velocith up to a given limit, and then the layer is set in motion. At this moment the sheet resistance sharply decreases, and with further increase in the velocity, it remains constant. The air stream velocity at which a sharp drop in pressure takes place and a constant sheet resistance is established is taken as the initial velocity for the optimal range of working velocities.

The dependence of the resistance of the grids with different free openings on the air stream velocity is shown in Fig. 2, and the dependence of the pressure **drop** of the layer of I on the air stream velocity and the height of the layer of I is shown in Fig. 3.

The data obtained show that  $\Delta P_{1r}$  increases with increase in the layer height and the air stream velocity. When a stream velocity of the liquefying agent of  $8\cdot 10^{-2}$  m/sec is



Fig. 4. Dependence of pressure drop (in mm Hg) on height of layer (in mm) at a constant blowing velocity of layer.

Fig. 5. Dependence of degree of decomposition of I (in %) on time (in min) at different temperatures. 1)  $156^{\circ}C$ ; 2)  $130^{\circ}C$ ; 3)  $100^{\circ}C$ ; 4)  $136^{\circ}C$ . 5)  $100^{\circ}C$ . Circles designate air-fluirized layer; crosses, the filtration regime.

reached,  $\Delta P_{1r}$  remains practically constant with further change in the air stream velocity. At air stream velocities above  $16 \cdot 10^{-2}$  m/sec, a considerable entrainment of the product takes place. The experimentally determined velocity at the beginning of air-fluidization is equal to  $8 \cdot 10^{-2}$  m/sec.

Increase in the sheet resistance for the height of the layer obeys the rectilinear law (Fig. 4), and hence

$$\Delta P_{\rm Ir} \simeq 0.55 H_{\rm Ir}.$$

The above relationship can be used to determine the  $\Delta P_{1r}$  and the initial velocity of motion of the particles with an accuracy sufficient for engineering calculations.

Theoretically, this (critical) velocity was calculated for calculated for crystalline ammonium nicotinate ( $\omega_{cr}$ ) from formulas recommended in the literature [2]:

$$Re_{cr} = \frac{Ar}{1400 + 5,22 \sqrt{Ar}}; \qquad Re_{cr} = \frac{\omega_{cr} dreq}{v};$$

$$\omega_{cr} = \frac{Ar v}{dr_{eq} (1400 + 5,22 \sqrt{Ar})};$$

$$Ar = \frac{g d^3 r eq \gamma_m}{v^2 \gamma_{air}},$$
(5)

(6)

where  $v = 15.06 \cdot 10^{-6}$  cm/sec<sup>2</sup> is the kinematic velocity of air, dr<sub>eq</sub> is the equivalent diameter of particles (100 µm) and  $\gamma_m$  and  $\gamma_{air}$  are the densities of the material and air.

The velocity value of  $\omega_{cr} = 6 \cdot 10^{-2}$  m/sec obtained is somewhat lower than the experimental value, since formula (5) does not take into account the adhesiveness of the particles due to roughness and the action of static electricity.

The working blowing velocity of the ammonium nicotinate layer is taken in the range from  $\omega_{cr1} = 8 \cdot 10^{-2}$  m/sec to the entrainment velocity of fine fraction  $\omega_{cr2} = 16 \cdot 10^{-2}$  m/sec.

The thermal decomposition of I was studied at 100, 136, and 156°C.

A known amount of I was charged into a preliminarily heated apparatus. The flow rate of air was determined from the velocity at the beginning of motion of the layer in the range used. The temperature of the material in the reaction zone was measured by a thermocouple at a "nonfluidized" layer. The temperature of the air was also measured before inflow into the layer and after it.

Figure 5 shows the dependence of the amount of liberated III on time at different temperatures.



Fig. 6. Comparison of calculated and experimental values of  $\alpha$ . Crosses - 100°C; circles - 136°; triangles - 156°C; squares - 136°C (filtration regime).

The results were processed by a topokinetic equation given in [3] and used in [1]:

$$\alpha = 1 - e^{-k\tau^n},\tag{7}$$

where  $\alpha$  is degree of decomposition of salt,  $\tau$  is duration of reaction (in min) and k and n are constants.

If we take n = 1, as in many topochemical reactions, we can obtain the values of K for different temperature regimes. At experimental temperatures of 100, 136, and 156°C, the values of K are equal to  $6.95 \cdot 10^{-2}$ ,  $1.3 \cdot 10^{-1}$ , and  $3 \cdot 10^{-1}$ , respectively.

At the corresponding values of K, the above equation (7) can be used to calculate the degree of decomposition of I with fair accuracy. The calculated and experimental values of  $\alpha$  are compared in Fig. 6. The deviation of the calculated data from experimental does not exceed  $\pm 7\%$ .

The rate of decomposition of I in a mobile layer is 2-3 times higher than in a stationary layer, so that the thermal decomposition of I can be appreciably intensified.

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INFLUENCE OF  $\gamma$ -IRRADIATION ON CONFORMATIONAL CHARACTERISTICS OF INSULIN MOLECULES IN MEDICINAL PREPARATIONS

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One of the most effective and promising methods used at present for the sterilization of medicinal preparations, including those of protein origin, is  $\gamma$ -irradiation. However, it is known that  $\gamma$ -irradiation can cause considerable damage to the structure of the molecules by both direct action and due to the presence of the products of the radiolysis of water. Compounds with a **peptide-protein** nature are specially sensitive to structural damage, since their biological activity depends not only on the degree of these or other disturbances in the chemical structure of the molecules, but to a great extent also on the conformational state as a whole. From the literature data available [1-8], it is known that during irradiation of certain proteins and peptides, degradation of individual amino acid residues can take place, as well as disturbances in the secondary structure of the molecules.

One of the most important medicinal preparations is insulin studied in the present work. The radiation sensitivity of insulin has been studied in fairly great detail. The

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