INFLUENCE OF HYDRODYNAMIC FACTORS ON THE OXIDATION

OF ISOPROPYLBENZENE FOAM

O. V. Maminov, A. Ya. Mutriskov,
V. V. Nesmelov, and N. N. Terpilovskii

UDC 532.5 : 66.094.3

The preparation of phenol and acetone from isopropylbenzene (IPB) involves the oxidation of cumene to the hydroperoxide (HPB). The kinetics and chemistry of this process were discussed in references [1-5].

In this article we shall discuss the influence of hydrodynamic factors on mass transfer (K, kg/m^2 · h · atm) and hydroperoxide formation rate (a, %/h) during batch liquid-phase oxidation of IPB foam by atmospheric oxygen. When IPB is oxidized on the grid of a foam apparatus, a stable-structured foam is formed, owing to the presence of surface-active substances (oxidation products) in the liquid phase. Oxidation was carried out for 2 h at 125°C, using partially oxidized IPB from the Kazan Organic Synthesis Factory (HPB content 5.5%, pH 6.5, n_D^{20} 1.4922) in a glass column 1.35 m high with internal diameter 0.04 m. We investigated the effects of the following factors on the coefficient of mass transfer and the rate of formation of HPB:

1) The diameter of the grid holes for constant effective cross section (f = 2.5%), d, mm;

2) the height of the load, h_0, m;

3) the velocity of the gas current over the total column cross section, w, m/sec.

We studied the kinetics of the process versus the grid hole diameter for a gas speed of w = 0.0316 m/sec and h_0 = 0.4 m. Here d_0 varied between 0.25 and 2.25 mm; when $d_0 \geq 1$ we observed liquid leaking through the holes in the grid.

In processing the experimental data we found the coefficient of mass transfer from the equation:

$$G_{O_2} = K\Delta pF, \tag{1}$$

where G is the amount of oxygen absorbed from the air in kg/h, F is the surface area of interphase exchange in m^2, and Δp is the mean logarithmic difference of the partial pressures of oxygen in fresh and spent air, in atm.

We calculated the interphase exchange area by a method described in [6]:

$$F = v \cdot f_{spec},$$

where v is the volume of the foam in m^3, and f_{spec} is the specific surface of the foam in m^2/m^3, equal to

$$6(1-\varphi_{liq})/d,$$

where d is the mean diameter of a bubble in the foam in m, and φ_{liq} is the proportion of liquid in the foam, equal to h_0/H (where H is the height of the foam in m).

Figure 1 plots the results of processing the experimental data. It will be seen that increase of d_0 has practically no effect on a, but causes an increase in K, apparently owing to increase in turbulence of the gas-liquid system with rising d_0 and reduction of the specific interphase exchange surface (which is inversely proportional to d). The dependence of K on d_0 follows a power law:
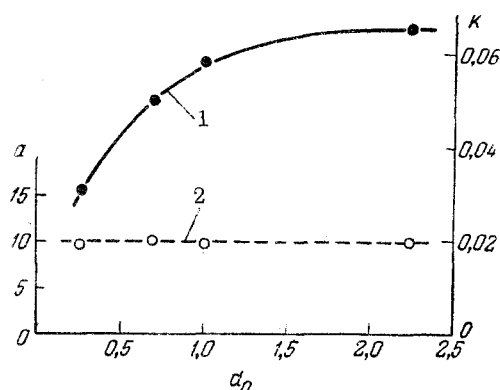
$$K = A \cdot d_0^n. \tag{2}$$

Fig. 1. Rate of HPB formation, a, and coefficient of mass transfer, K, versus diameter of grid holes, d_0. 1) K versus d_0; 2) a versus d_0.
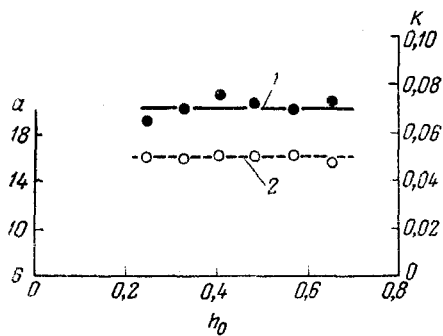

Fig. 2. Rate of HPB formation, a, and co-efficient of mass transfer, K, versus depth of load, h_0: 1) K versus h_0; 2) a versus h_0.
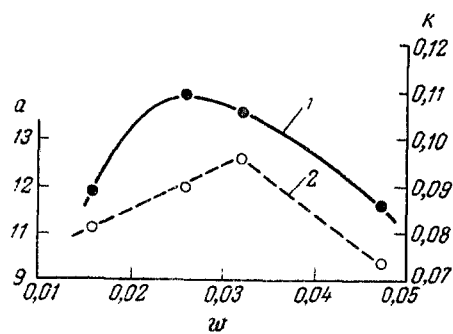
Fig. 3. Rate of formation of HPB, a, and co-efficient of mass transfer, K, versus gas velocity in column w: 1) K versus w; 2) a versus w.

For our system, the numerical values of the coefficient are: A = 0.61, m = 0.35. The influence of load height on K and a was investigated for w = 0.0467 m/sec, d_0 = 0.7 mm. Here h_0 was varied between 0.24 and 0.64 m.

Figure 2 plots K and a versus h_0. It shows that both the coefficient of mass transfer and the rate of oxidation of IPB to HPB are practically independent of the load height.

We studied the influence of w on K and a, with d_0 = 0.7 mm and h_0 = 0.4 m, and w varying between 0.015 and 0.0467 m/sec.

The results of processing the experimental data are plotted in Fig. 3, from which we see that as w increases, the coefficient of mass transfer and the rate of oxidation of IPB to HPB at first increase, and then begin to decrease. This is due to changes in the hydrodynamic state of the system as the speed of the gas current in the column varies.

For low values of w, bubbling sets in at the column grid; when w > 0.02, a structured foam forms. The maxima on the K and a curves are associated with breakup of the structured foam at w > 0.04 m/sec.

Thus our results imply that in batch liquid-phase oxidation of IPB to HPB in a sieve-plate column, the coefficient of mass transfer and the rate of formation of HPB depend mainly on the hydrodynamic state of the system. The maximum values of K and a occur when the two-phase system is in the foam state. In this state, the load (if the ratio of the load height to the column diameter is less than 1/15) has practically no effect on the process kinetics.

LITERATURE CITED

1. K. I. Ivanov and E. D. Vilyanskaya, Khim. i Tekhnol. Topliv i Masel, No. 4 (1957).
2. S. D. Kaz'min and R. V. Kucher, Kinetika i Kataliz, 2, 422 (1961).
3. V. L. Antonovskii and B. I. Makalets, DAN SSSR, 140, 1070 (1961).
4. R. V. Kucher, ZhPKh, 35, 170 (1962).
5. V. A. Shushunov, B. A. Redoshkin, and Yu. D. Golubev, ZhPKh, 35, 832 (1962).
6. O. V. Maminov, Trudy Kazanskogo Khimichesko-Tekhnologicheskogo Instituta, No. 27, 132 (1961).