



Soviet-era science, translated into English

Physical Chemistry

S. M. Kogarko and B. A. Ivanov

1961

SovietRxiv

View the original and related papers at <https://sovietrxiv.org/items/ru-196101.46561>

Source: Math-Net.Ru and CyberLeninka. Machine translation. Verify with the original.

Abstract

Full Text

Physical Chemistry

S. M. Kogarko and B. A. Ivanov

On the Limiting Pressure for Spontaneous Propagation of a Reaction Zone in Acetylene

(Presented by Academician V. N. Kondrat'ev, April 5, 1961)

At present, on the basis of numerous data in the literature, it is generally accepted that the limiting pressure at which spontaneous propagation of a reaction zone from the ignition site is still possible in pure acetylene corresponds to a pressure of 1.35–1.40 ata. Analysis of the literature data shows that the energy required to initiate the decomposition of acetylene in a volume considerably exceeds the amount of energy used for ignition even of limiting fuel-air mixtures. In addition, the amount of energy required to initiate the decomposition of acetylene depends strongly on pressure; when the pressure is decreased, it increases. It is also well known that an ordinary electric spark, used for igniting fuel-air mixtures, cannot create in acetylene the reaction zone necessary at a given pressure, which could propagate spontaneously throughout the entire volume even at an initial pressure of 4–5 ata.

It should also be mentioned that the limiting diameters of tubes in which spontaneous propagation of a reaction zone in acetylene becomes possible are very large in comparison with the limiting tube diameters for fuel-air mixtures. Thus, at a pressure of 1.4 ata the limiting diameter of a tube is 60 mm; at a pressure of 12 ata it is 8 mm, whereas for fuel-air mixtures the limiting diameter of tubes does not exceed one millimeter.

All these data indicate that the width of the zone of chemical reaction propagating spontaneously through acetylene is considerably greater than all values known to us for fuel-air mixtures.

Since, in the technical use of acetylene, especially when it is transported through pipelines under elevated pressure, ignition sources of the most varied form and power may arise (spark, static electricity, burner flame, etc.), the experimental determination of the minimum pressure at which spontaneous propagation of the reaction zone throughout the entire volume filled with acetylene is still possible becomes of substantial importance.

The investigation of acetylene decomposition at various initial pressures was carried out in a steel tube 160 mm in diameter and 1500 mm long, i.e., its volume was 30 l. To observe the propagation of the reaction zone through the acetylene, the tube was provided with four windows, each 250 mm long, which

Fig. 1

Figure 1: Fig. 1

Fig. 2

Figure 2: Fig. 2

were closed with Plexiglas plates. The propagation of the reaction zone from the ignition site along the entire length of the tube was recorded on photographic film fixed on the rotating drum of a photorecorder. For a control experiment a steel tube 400 mm in diameter and 20 meters long was used, i.e., its volume was 2500 l. Initiation of acetylene decomposition was carried out at one end of the tube either by means of a nichrome coil heated to red heat, or by means of a capacitor discharge across the gap between two electrodes placed in the acetylene under study, or by burning in acetylene a certain amount of an explosive mixture in a thin rubber sheath. The experimentally determined value of the pressure at the lower limit did not depend on the type of ignition source used in the experiment.

Fig. 1. Propagation of flame in acetylene. Initial pressure 640 mm Hg. Tube diameter 160 mm, length 1500 mm. Ignition by a heated nichrome spiral

Figure 1 shows, for illustration, a typical photographic record of the propagation of the reaction zone in acetylene.

The length of the tube is plotted along the ordinate axis, and time along the abscissa axis. As can be seen from the photographic record shown, the interval of time from the beginning of the glow of the nichrome wire to the beginning of the visible propagation of the flame is approximately 1.1 sec.

Fig. 2. Dependence of the limiting initial pressure of acetylene on the energy of the initiating spark. Tube diameter 160 mm, length 1500 mm

Figure 2 presents, in graphical form, the experimental dependence obtained in the experiments of the minimum pressure at which formation and spontaneous propagation of the reaction zone are possible, on the energy of the spark used to initiate the decomposition of acetylene. Analysis of the dependence shown in Fig. 2 indicates that spontaneous propagation of the reaction zone in acetylene is possible down to a pressure of 580 mm Hg, i.e., to a pressure of 0.76 ata, and not to 1.35-1.40 ata, as is usually stated in the literature. From these experimental data one can estimate the width of the reaction zone in acetylene. At a pressure of 580 mm it proved to be approximately 16 mm, i.e., considerably greater than in ordinary fuel-air mixtures. The discrepancy between the value of the lower limiting pressure for acetylene obtained by us and that accepted in the literature is explained by the fact that the sources used in the published works to initiate the decomposition of acetylene were insufficient and could heat only such a layer of gas as was equivalent to the actual reaction zone in acetylene

at an initial pressure of 1.35-1.40 ata.

If, when decomposition of acetylene is initiated by an electric spark, a heating zone corresponding to the actual reaction zone during its spontaneous propagation can be created in the gas at once, then, when initiation is by a heated nichrome spiral, ignition of a certain volume of acetylene first occurs, and only afterward is a heated layer corresponding to the reaction zone formed.

At an initial pressure of 1.0 ata, an experiment was carried out on the decomposition of acetylene in a tube 400 mm in diameter and 20 m long. Initiation of the decomposition of acetylene was carried out at one end of the tube by means of a discharge

of the capacitor through a spark gap. The reaction zone propagated along the entire length of the tube with an average velocity of 30 m/sec.

The experimental material obtained in this work confirmed our assumptions regarding the large width of the reaction zone in acetylene during its spontaneous propagation and the need to use initiating sources of considerably greater power than those used for the ignition of ordinary fuel-air mixtures. To create safe conditions when working with acetylene, it is necessary to take into account the lower limiting pressure value obtained in this work, at which spontaneous propagation of the decomposition zone arising at one point in the system throughout its entire volume is possible.

Institute of Chemical Physics
Academy of Sciences of the USSR

Received
31 III 1961

Note: Figure translations are in progress. See original paper for figures.

Source: Math-Net.Ru and CyberLeninka. Machine translation. Verify with the original.