Austin Environmental Sciences

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Mini Review

Dissociation of CO_2 into C and O_2

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Received: November 11, 2021; **Accepted:** January 03, 2022; **Published:** January 10, 2022

Abstract

The objective of the research was to test the possibility of dissociating CO_2 into C and O_2 using electric discharges. An apparatus was designed and constructed for this specific purpose, and then CO_2 was subjected to high-energy electrical discharges. After dissociation was completed, the gas "bombarded" with electric sparks was analyzed in a gas chromatograph. The obtained results indicate that about 17% oxygen, 72% nitrogen, and 0.9% Argon was obtained from dissociated CO_2. About 8.5% of CO_2 did not dissociate.

The experiments and measurements of the obtained products, repeated several times, also revealed trace amounts of methane in the products of dissociation.

Keywords: CO_2; Chromatograph; Bombarded

Introduction

The method of gas, in particular CO_2, dissociation used and described here focused on bombarding the gas with electric discharges. In this process CO_2 acts as a dielectric. The energy released during controlled electric discharges breaks the interatomic bonds between the oxygen and carbon atoms.

It is obvious that the energy of these electric discharges bombarding the gas needs to fulfill the necessary condition for the dissociation of the compound, i.e. the energy necessary to break very strong bonds between oxygen and carbon atoms, division into components and distancing them from each other so that they stop interacting with each other. This energy should be within the range of values of the binding energy of atoms in the carbon dioxide molecule (about 1070kJ/mol) and the enthalpy of formation, i.e. the energy needed to create the CO_2 system (about 1650kJ/mol). Dissociation of exhaust gases, especially CO_2, occurs by bombardment with high energy and possibly high frequency electric charges.

During an electric discharge, processes that take place lead to excitation of molecules and then return to lower energy states, ionization and, consequently, recombination of ions and electrons. While moving in the dielectric medium, in CO_2, the electron is subject to many collisions with gas atoms, which is accompanied by transfer of the electron's energy to gas atoms. The effect of these collisions is ionization of gas particles, as well as their excitation and change of kinetic energy.

The dissociation process was carried out under conditions of increased pressure (0.1-1 MPa above the value of atmospheric pressure), which allowed for increased ionization, and the resulting electric discharges in the gas at such a pressure value take the form of brightly shining plasma channels with high current intensity and low voltage drop. The electric spark generated in the discharges leads to an avalanche of ionization of gas molecules. It is accompanied by an acoustic wave, strong glow of the plasma channel and its high temperature (approx. 10,000 K).

The flow of charges between the electrodes leads to equalization of potentials and ends the discharge. The energy obtained in this way is greater than the enthalpy of the CO_2 compound formation and causes permanent separation of its atoms through loss of bond stability. This is followed by breaking the bonds leading to the separation of C from O_2. This can happen through the stage of free CO formation from CO_2 or immediate formation of C and O_2.

Description of Dissociation

In the experiment a glass bulb with four electrodes was used, closed with two vacuum valves (Figure 1A). It was filled with pure CO_2 from a bottle. An electric discharge generator was designed and constructed for the experiment (Figure 1B). The current generated in it was transmitted to the glass bulb using cables. There, flowing between the electrodes, it caused the formation of electric discharges dissociating CO_2 (Figure 1C).

After dissociation was completed, the gases formed from CO_2 were transferred to a special vacuum container (Figure 1D). The container with dissociation products was connected to the gas chromatograph (Figure 1E) in which the gaseous dissociation products were determined.

CO_2 dissociation was performed several times, as was determining its products.

The obtained results indicate that about 91.5% of CO_2 bombarded with electric discharges was converted into nitrogen, oxygen, argon and traces of methane (Figure 1F and Table 1). It was determined that oxygen is present in the dissociation products in the amount of 17.5%. The main product of this dissociation process, however, is nitrogen (about 72.5%).

Extremely interesting are the identified trace amounts of methane (CH_4) in the dissociation products, proving the possibility of its synthesis not only as a transformation product of organic compounds of biological origin, but also in the synthesis of inorganic compounds.

Discussion of the Results

Obtained results prove that in this experimental dissociation method 90% of carbon dioxide is converted mainly into nitrogen and

Citation: Pawlikowski M. Dissociation of CO_2 into C and O_2. Austin Environ Sci. 2022; 7(1): 1067.

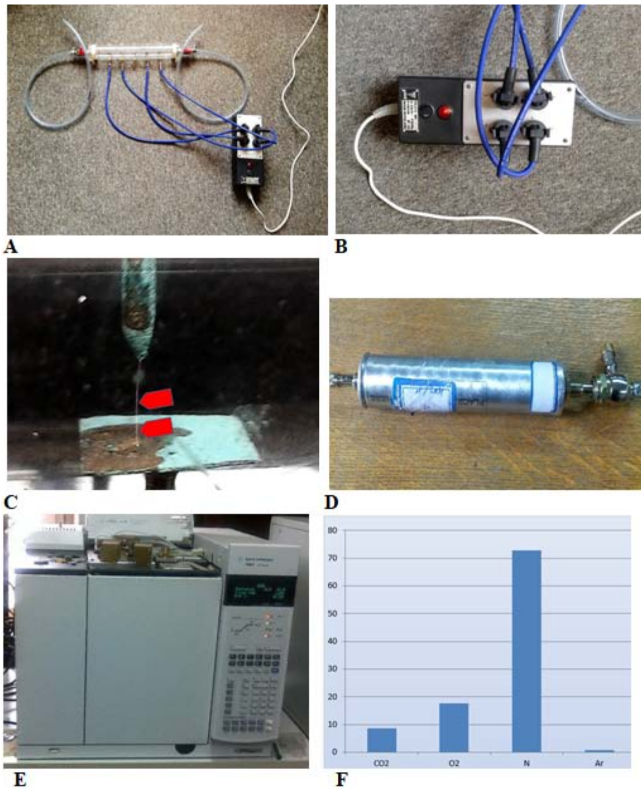

Figure 1: A) Vacuum glass bulb with electrodes and valves, where CO_2 dissociation was carried out. B) Voltage generator for the electrodes in the glass bulb. C) Photo of the dissociation process. The plasma beam (red arrows) in the process of high-frequency electric discharges runs between the electrodes, causing CO_2 dissociation. D) Container for transferring CO_2 dissociation products from the glass bulb to the chromatograph. E) Chromatograph used for gas analysis. F) Diagram of the composition of dissociation products.

Table 1: Results of dissociation of CO_2.

CO_2	8.57
O_2	17.64
N	72.68
Ar	0.91
CO	0.19

oxygen.

The phenomenon of nitrogen formation in the atmosphere is known from its upper layers. There, under the influence of neutrons in cosmic radiation, the process of transformation of ^{14}N into radioactive ^{14}C continuously occurs, as illustrated by the following reaction:

$$n+{}^{14}_{7}N \rightarrow {}^{14}_{6}C+{}^{1}_{1}H$$

This carbon, after reacting with atmospheric oxygen, forms $^{14}CO_2$ which, during assimilation, penetrates into plant structures, remaining in them until they die. Then the carbon isotope decays as illustrated by the reaction:

$${}^{14}_{6}C \rightarrow {}^{14}_{7}N+e^{-}+v_e$$

Isotope studies of the nitrogen obtained as a result of the described dissociation have not been conducted. It can be assumed that at least some of it may be of a similar nature.

Summary

The research conducted proves the possibility of reducing a significant amount of CO_2 generated in various technological processes. An important issue is that of energy consumption and economic profitability of dissociation. The process becomes profitable when renewable electricity from wind farms or photovoltaic panels is used for dissociation. Electricity consumed during periods of its excess in the energy system will also significantly improve the economics of the process.

A separate and interesting issue is the synthesis of methane in the process of CO_2 dissociation.

This phenomenon, as well as the increase in efficiency and profitability of the tested process, requires further, additional research.