

TITLE: CO₂ SEPARATION BY PHASE ENHANCED ABSORPTION

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ABSTRACT

A new process called phase enhanced gas-liquid absorption has been developed in its early stage. It was found that adding organic phase into the absorption system of gas/aqueous phase could enhance the absorption rate.

A system with three phases was studied. In the system, gas phase was carbon dioxide. Two liquid phases were used. One was organic phase. Another was aqueous phase. By addition of organic phase into the absorption system of CO₂-aqueous phase, the absorption rate of CO₂ was increased significantly. CO₂ finally accumulated into aqueous phase. The experimental results proved that

- (1) Absorption rate of carbon dioxide was enhanced by adding organic phase into gas-aqueous phase system;
- (2) Organic phase played the role of transportation of gas solute (CO₂). Carbon dioxide finally accumulated into aqueous phase.

Definitions and Basic Concepts

Absorption is a process by which one or more components of a gas mixture are transferred to a liquid where it is soluble. The operation of absorption can be categorized on

the basis of the nature of the interaction between absorbent and absorbate into following two types, traditionally:

Physical absorption: The component being absorbed in physical absorption is more soluble in the liquid absorbent than other gas components with which it is mixed, but does not react chemically with the absorbent.

Chemical absorption: Chemical absorption is characterized by the occurrence of a chemical reaction between the gas component being absorbed and a component in the liquid to form a compound.

Phase enhanced absorption or Phase enhanced gas-liquid absorption: In the study, it was found that by adding an organic compound or mixture into a gas-liquid (frequently, an aqueous phase) absorption system, the absorption rate of the gas can increase significantly. Therefore, the process occurring in this system is referred to as phase enhanced gas-liquid absorption. In phase enhanced gas-liquid absorption, more than one liquid phase was involved in absorbing the gas. One of the liquids serves as an absorbing carrier where the gas is finally accumulated. The other liquid, the transportation layer, plays a role of transporting the gas from the gas mixture to the carrier and increasing the absorption rate of the gas.

The following experiments were designed to study the phase enhanced absorption:

Absorption Rate of Carbon Dioxide in the Organic Mixture and in the Liquid Carrier

The experiments were conducted to determine the effects of the transportation layer. Carbon dioxide absorption rates in a liquid carrier and in an organic mixture were measured individually under the same experimental conditions: $T=25\text{ }^{\circ}\text{C}$, $p=1.0\text{ atm}$, carbon dioxide concentration=99.9% by volume, agitation speeds = 250 and 106 rpm (for two different runs). The liquid carrier was made of 300 ml of 400 g/L sodium formate aqueous solution and the organic mixture was 300 ml Alamine 336 and 2-ethylhexyl alcohol (1:1 ratio by volume).

The results from those experiments are shown in FIG. 5A and 5B. Carbon dioxide was absorbed by the organic mixture much faster than it was by the liquid carrier. FIG. 5A shows different absorption rates for the two experiments performed with agitation speed being 250 rpm. FIG. 5B shows the result from the two experiments conducted at the agitation

speed of 106 rpm. It can be seen that the absorption rate of carbon dioxide in the liquid organic mixture was about ten times more than that in the liquid carrier.

By comparing the absorption rates in FIGS. 5A and 5B, it is apparent that when the liquid carrier and the organic mixture existed in the same gas-liquid absorption system, the slow absorption of carbon dioxide by the liquid carrier did not limit the rate at which carbon dioxide was absorbed under the experiment condition.

The relationship between the absorption rate of carbon dioxide and absorption time is shown in FIGS. 6A and 6B. It is obvious that carbon dioxide reached equilibrium in the liquid organic mixture much earlier than that in the liquid carrier. So, the organic mixture was saturated by carbon dioxide much earlier than by the liquid carrier when both existed in the same system.

The experimental results also shows that the mass transfer resistance of carbon dioxide in the organic mixture was much lower than that in liquid carrier.

CO₂-sodium Formate Aqueous Solution Absorption System

In this example, two experiments were conducted. In the first experiment, carbon dioxide was absorbed by 280 ml sodium formate aqueous solution (400 g/l) and 20 ml organic mixture of Alamine 336 and 2-ethylhexyl alcohol (1:1 by volume). In the second experiment, carbon dioxide was absorbed by 300 ml sodium formate aqueous solution (400 g/l) directly.

In the first experiment, 280 ml sodium formate aqueous solution (400 g/L) and 20 ml liquid organic mixture were added into the reaction vessel. The liquid organic mixture, which was immiscible with the aqueous solution, formed a layer, as a second liquid phase, on top of the liquid carrier. The liquid carrier was agitated gently to facilitate the diffusion or dissolving of the gas. Agitating was sufficiently gentle so the convection moment it created did not break or destroy the layer of the liquid organic mixture. Carbon dioxide from the gas had to pass through the layer of the organic mixture in order to enter the aqueous solution. In the second experiment, 300 ml sodium formate aqueous solution (400 g/L) was introduced into the reaction vessel. No liquid organic mixture was added. Both experiments were conducted under the same experimental conditions: temperature=25 °C, pressure=1.0 atm, agitation speed=250 rpm, and the concentration of carbon dioxide=99.9 % by volume.

FIG. 4 shows that the absorption rate of carbon dioxide in the first experiment was higher than that in the second experiment. Clearly, the sodium formate aqueous solution absorbed carbon dioxide faster in the presence of the liquid organic mixture than it did in the absence of it.

FIGURE 4

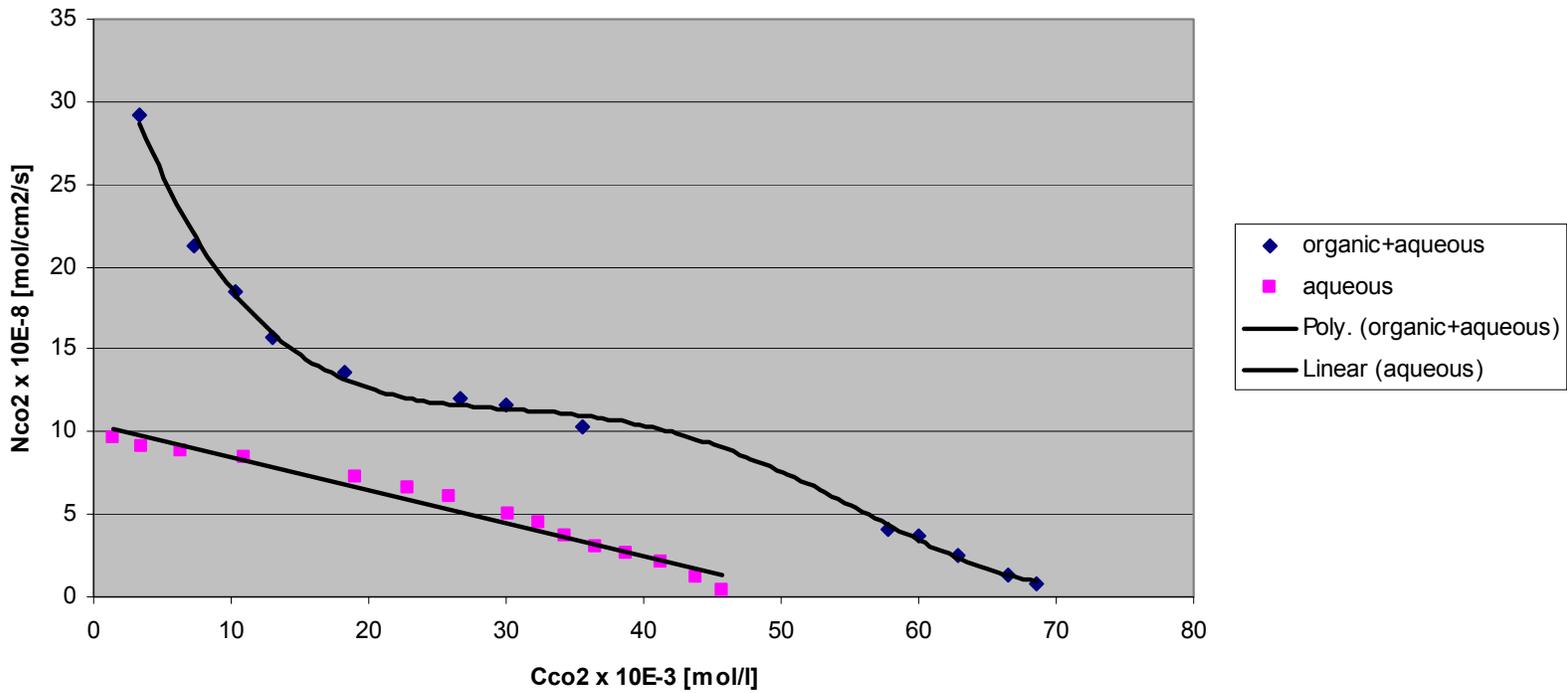


FIGURE 5 A

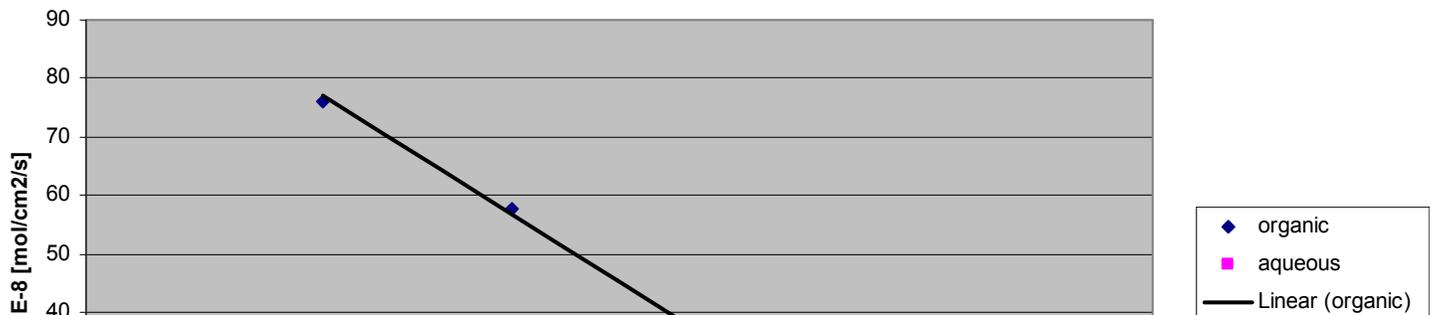


FIGURE 5 B

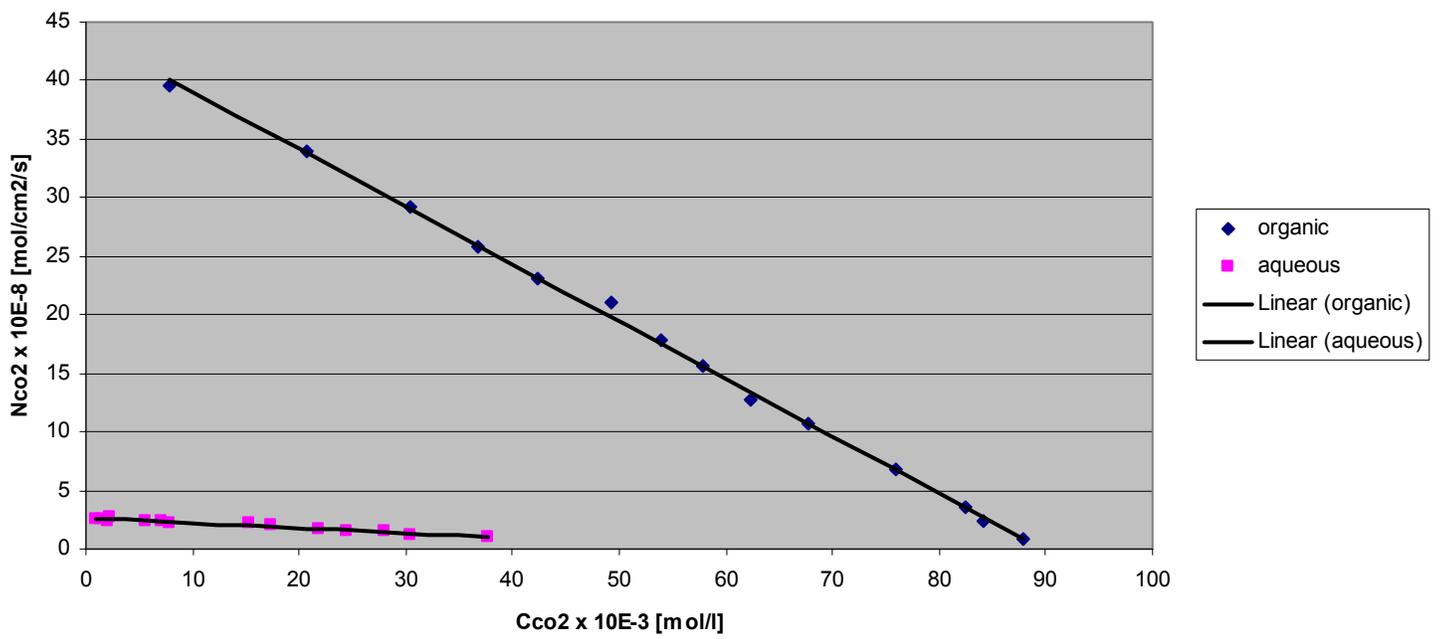


FIGURE 6 A

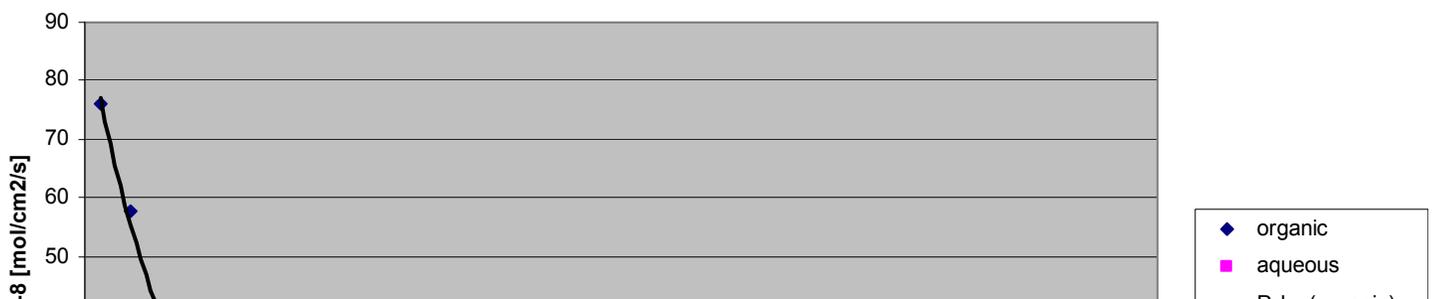


FIGURE 6 B

