NASA TECH BRIEF
Ames Research Center

Solid Amine Compounds as Sorbents for Carbon Dioxide — A Concept

Solid amine compounds have been studied as possible absorbents for removal of carbon dioxide in life support systems of the type which may be employed in high-altitude aircraft, spacecraft, or submarine vessels. Of particular interest is the fact that many solid amine compounds release absorbed carbon dioxide when heated in vacuum. Thus, when packaged in appropriately designed units, spent amine compounds can be readily regenerated and put back into service.

Currently available solid amine compounds also possess an affinity for water vapor; thus, the amines are suitable candidates for life support systems inasmuch as nearly equal weights of water and carbon dioxide are produced during normal human activity. However, the constant removal of water may dehumidify ventilation loops excessively because a pilot, astronaut, or diver wearing a suit that is liquid cooled generates only half as much water as the weight of carbon dioxide released. Excessive dehumidification not only causes personal discomfort but also reduces the capacity of the sorbent for the removal of carbon dioxide. Fortunately, as will be explained below, the rate of removal of water and carbon dioxide can be controlled by adjusting the relative amounts of the types of amines in a sorbent mixture.

In general, the reaction of solid amine compounds with carbon dioxide in the presence of water forms carbonates; for example, the various types of amines could possibly react as follows:

Primary amines

1) $RHN_2 + H_2O \rightleftharpoons RHN_3OH$
2) $RHN_3OH + CO_2 \rightleftharpoons RHN_2 \cdot HCO_3$

Secondary amines

3) $R_2NH + H_2O \rightleftharpoons R_2NH_2 \cdot HCO_3$
4) $R_2NH_2OH + CO_2 \rightleftharpoons R_2NH \cdot HCO_3$

Tertiary amines

5) $R_3N + H_2O \rightleftharpoons R_3NHOH$
6) $R_3NHOH + CO_2 \rightleftharpoons R_3NH \cdot HCO_3$

However, experiments have shown that equation (1) is not reversed during regeneration and equation (6) does not proceed to any substantial degree. Hence, by using appropriate amounts of each of the three amine-types, a given ratio of water vapor absorption to carbon dioxide absorption, as well as total bed capacity, should be obtainable.

It is anticipated that a thin coating of a mixture of amine compounds can be deposited on an inert carrier to form a stable absorbent bed. A typical canister design requires packaging of the amine mixture within the flow passages of a brazed plate-fin matrix. The matrix would consist of four alternating-flow passages (two absorbing and two desorbing) separated by closure panels and parting sheets. Heat would be transferred from the absorbing to the desorbing passages by sheared rectangular fins which can be arranged to prevent channelling. Each header in the unit would be equipped with a mesh screen and preload padding to facilitate bed charging and to provide a preload on the bed.

The incorporation of alternate flow passages containing absorbing and desorbing material provides an isothermal absorb-desorb process; energy released from the absorbing passages would be transferred by conduction through the metal matrix to desorbing

(continued overleaf)

material to supply energy for the endothermic desorption process. The entire sorption-desorption process does not impose a thermal load on thermal control subsystems and it does not require additional energy for regeneration; moreover, it also provides humidity control.

Note:

Requests for further information may be directed to:

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No patent action is contemplated by NASA.

Source: James G. Sutton, Philip F. Heimlich, and Edward H. Tepper of United Aircraft/Hamilton Standard Division under contract to Ames Research Center (ARC-10571)