

Sofnolime Versus Sodasorb, Bench Test Comparison

Deanna Monahan Burton and Francisca Boltinghouse
Applied Biomedical Engineering Laboratory
Pembroke, Virginia 24136

ABSTRACT

Two commercially available **sodalime-type CO₂ scrubber** products were compared for application in recirculatory respiratory systems. Carbon dioxide absorption capacity, useful absorption duration times, mesh **size**, and percent moisture content were compared under dry and humidified breathing gas conditions for Sodasorb and Sofnolime brand products. No difference between the two brands was found in the rate of reaction with both brands providing equivalent results for equivalent particle mesh sizes. The smaller available mesh size (8-10; USA Standard) absorbs **CO₂** at a faster rate than the 4-8 mesh, but the total amount of **CO₂** absorbed is independent of mesh size. Sofnolime high moisture products absorb a higher percentage of **CO₂** than any of the Sodasorb products tested and the Sofnolime high moisture products were relatively insensitive to feed gas humidity. Overall **Sofnolime** is a more **efficient** and versatile product for use in **recirculatory** respirators than is Sodasorb.

Introduction

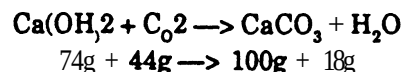
Calcium hydroxide scrubbers, commonly known as **sodalimes**, are the most **frequently** chosen carbon dioxide absorbent for recirculatory respirator systems. The low **cost**, ease of **use**, safety, and low **exotherm** (less than half that of most other commonly used scrubbers) makes them preferable for most conventional applications. **Currently** two major brands are available; Sodasorb (WR Grace and Company, New York, New York) and Sofnolime (Molecular Products, Ltd. **Thaxted**, Essex, England). The results reported herein were obtained as part of a larger study to evaluate the feasibility of reducing excess water and heat generation at higher metabolic work loadings in closed circuit Self Contained Breathing Apparatus. The purpose of the sodalime studies was to establish **testing procedures** and provide a baseline against which new formulations can be evaluated.

Testing Procedures:

Two basic testing procedures have been established to test **CO₂** scrubbers: (1) a slow reaction test which measures the maximum carbon dioxide capacity of the **scrubber** and provides a qualitative absorption rate comparison and (2) a fast reaction test used to compare efficiency of the scrubber in completely removing a gas stream of carbon dioxide.

Figure 1 outlines the equipment set up for the slow reaction procedure. A controlled sample weight of scrubber (10 g for scrubbers in granule form) is placed on an electronic balance that has a minimum readability of 0.001 grams. The sample is covered and flushed at a constant flow rate with 9% **CO₂** in oxygen (**CO₂** = 100 ml/min, **O₂** = 1,000 ml/min). The resulting graph of time versus change in weight can be used to compare the rate of reaction of various scrubber materials.

Some scrubber samples contain a percentage of water. The controlled sample weight (10 grams) is the dry base material. Once a test is completed, the reacted sample is dried in an oven at 93°C to remove the water produced in the **CO₂** metal hydroxide reaction. The change in weight from the original dry weight to reacted dry weight can be used to calculate the grams of **CO₂** absorbed during the test. A sample calculation is shown using a **Ca(OH)₂** test run as the example. Looking at the reaction and corresponding molecular weights:



In this example, if 74 **g/mole** is the starting base material, then for each mole of **CO₂** absorbed, 100 **g/mole** of dry material remains, giving a dry weight **difference** of 26 **g per mole** of **CO₂** absorbed. Using the relationship and calling the **difference** dry weight **W_d**, the following calculations is made to **find** the grams of **CO₂** absorbed:

Slow Reaction Testing Equipment Setup

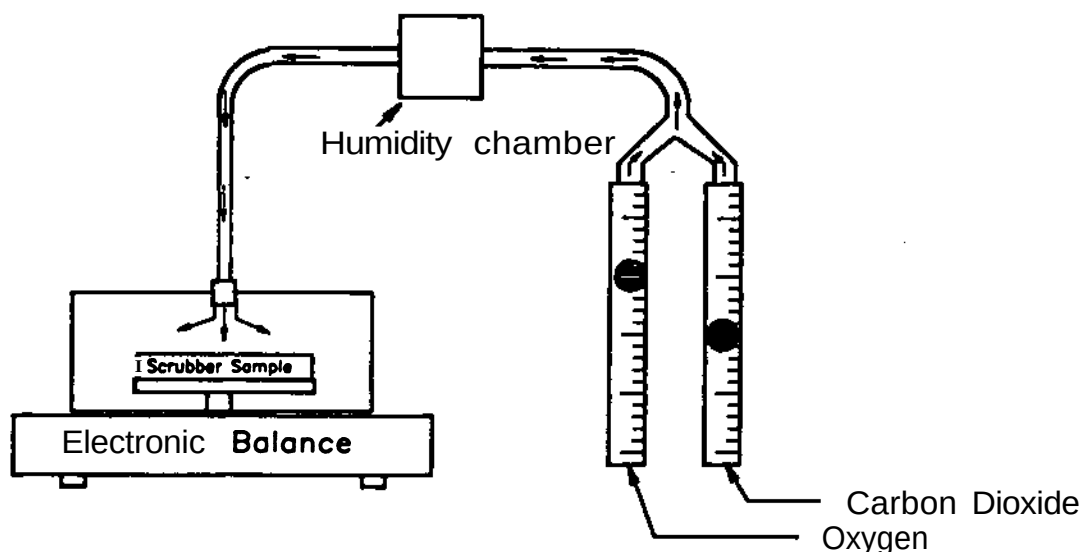


Figure 1

$$5.3g W_d * [1 \text{ mole } CO_2 / 26g W_d] * \\ [44g CO_2 / 1 \text{ mole } CO_2] = 9.0g CO_2$$

Figure 2 is a schematic for the fast reaction test setup. The scrubber is tightly packed into a 21 cm by 3 cm internal diameter cylindrical bed through which 9.0% CO_2 is passed at 2,200 ml/min (twice the rate of the slow testing procedure). The duration to initial **breakthrough**, the rate of increase to 4% CO_2 , maximum exit gas temperature, and the maximum scrubber bed temperature are compared under humidified and **dry** conditions for equal volumes of various test scrubbers.

Comparison of *Commercial* Scrubbers

Several Sofnolime samples were obtained: 1) high moisture content (**15% - 20%**) products in mesh sizes 4-8 (USA Standard Testing Sieves) and **8-10**, 2) low moisture content (**6% - 8%**) product in mesh sizes 4-8 and **8-10**. For convenience in the following report, the high moisture products are designated Sofnolime **HM** and the low moisture products designated Sofnolime **LM** followed by the appropriate mesh size. The Sodasorb product is readily available only as Sodasorb HM (high moisture) and Sodasorb HP (high performance) mesh size **4-8**. Other types and mesh sizes are available from **WR** Grace on a special

order, large quantity basis and **were**, accordingly, not tested. Sodasorb HP is also a high moisture version in which raw materials of higher purity are used than are used in Sodasorb H. To compare **different** mesh sizes the two Sodasorb products we crushed by hand and sieved to **8-10** mesh size.

Slow Reaction Testing:

During the testing with the slow reaction equipment both brands of high moisture Sodalime absorbed carbon dioxide at equal rates. The mesh size did effect the rate of absorption under both dry and humidified conditions. Mesh size 8-10 scrubbers absorbed CO_2 at a faster rate and reach their peak more quickly than the 4-8 mesh size. This is due to the increased outer surface area of the smaller 8-10 mesh size scrubber. The difference in rate absorption between the **8-10** and 4-8 is less when the 9% CO_2 gas feed is humidified and the rates are slightly faster compared to the tests using dry feed gas. Figure 3 is a graph representing the general patterns of time versus change in weight as the scrubber absorbs CO_2 . Sofnolime LM **8-10** scrubber has a fast rate of CO_2 absorption, as do the other **8-10** high moisture scrubbers but the peak of absorption is reached considerably earlier, showing a shorter reaction time than

Fast Reaction Equipment Setup

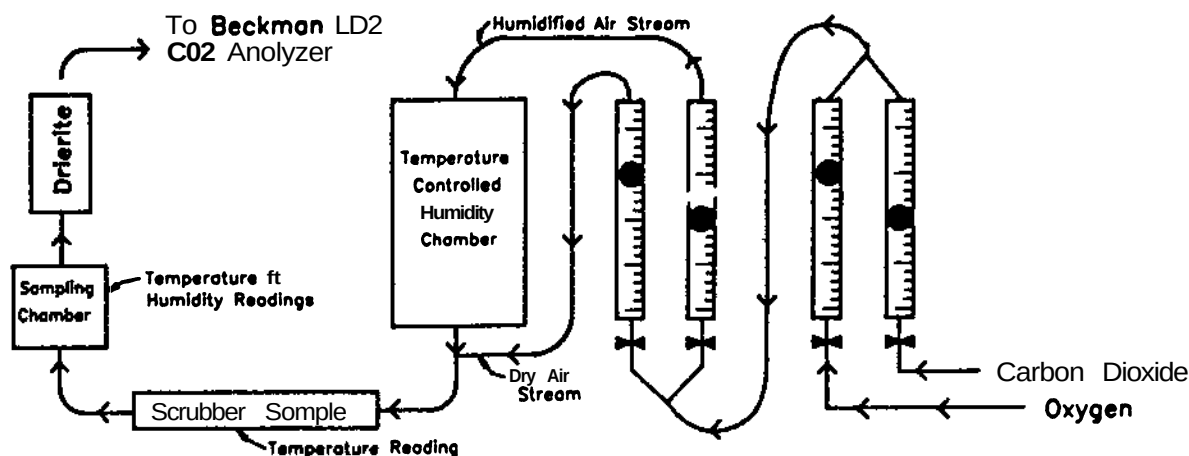


Figure 2

any other samples.

Figure 4 compares the total weight of CO_2 absorbed by different scrubbers. The total CO_2 absorption is independent of product mesh size. In this comparison the Sofnolime HM products consistently absorb 12% more CO_2 , under dry conditions and 3% more CO_2 under humidified conditions than the Sodasorb products. All scrubbers showed an increased CO_2 capacity when using humidified gases as compared with dry gases, with Sofnolime LM showing the greatest change. The Sofnolime LM 4-8 exhibited a substantial increased absorption from 12% to 57% while the 8-10 mesh size only increased from 48% to 65% of the theoretical capacity. A 15% increase in absorption was observed in the Sodasorb products when testing with humidified gases. The Sofnolime high moisture scrubbers were not as sensitive to the condition of the feed gas; the CO_2 capacity only increased 3% when changing from dry to humidified gas streams.

Sofnolime HM also is superior to the Sodasorb products in the fast reaction testing. Figure 5 compares the time vs. CO_2 breakthrough, for the dry condition tests. Using equal volumes of scrubber, the time to initial breakthrough of the Sofnolime HM products are on an average 35% longer than the Sodasorb products. This is consistent with the initial slow reaction test results which showed that an

equal weight of Sofnolime HM will absorb a greater amount of CO_2 than the Sodasorb products. Mesh size has the same effect on performance in the dry condition fast reaction series of tests as in the slow reaction tests. The smaller 8-10 mesh shows a longer time to initial breakthrough, then increases to 4% CO_2 more rapidly than the same scrubber in the larger 4-8 mesh size. Mesh size has no significant effect on the amount of CO_2 absorbed at 4% breakthrough by any particular scrubber.

Humidified air lengthens the time to the initial 0.1% breakthrough and to the 4.0% breakthrough. The initial CO_2 breakthrough times for humidified gases are dependent on mesh size with the 4-8 mesh breakthrough time being shorter than that of the 8-10 mesh size just as when using dry feed gas. The major difference between humidified and dry gases is that the rate of rise from 0.1% breakthrough to the 4.0% CO_2 concentration level is independent of mesh size. The Sofnolime HM products have longer breakthrough times and increased CO_2 absorption than the Sodasorb products for both dry and humidified results. The percentage of theoretical capacity for all scrubbers rose slightly from the dry to the humid tests with the Sodasorb products exhibiting a larger change than the Sofnolime.

Sofnolime LM showed a 60% increase in the time to

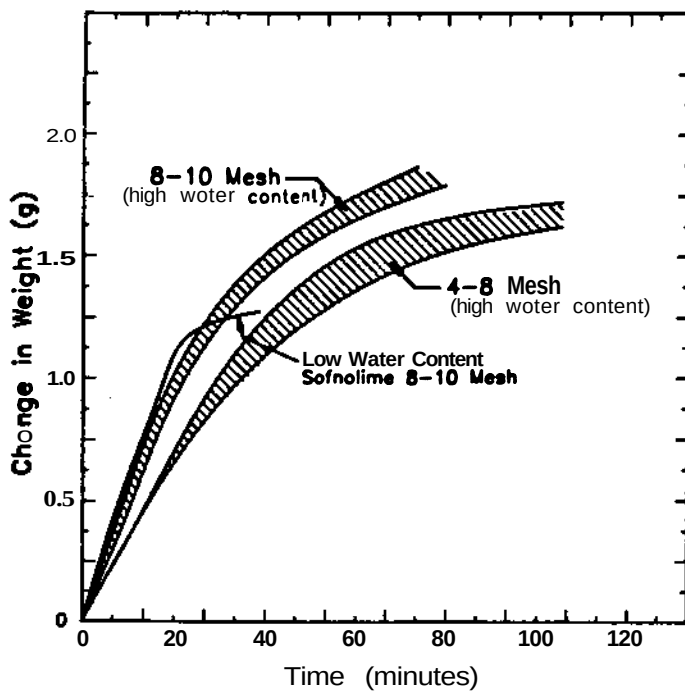


Figure 3

General Pattern of Stow Reaction Results

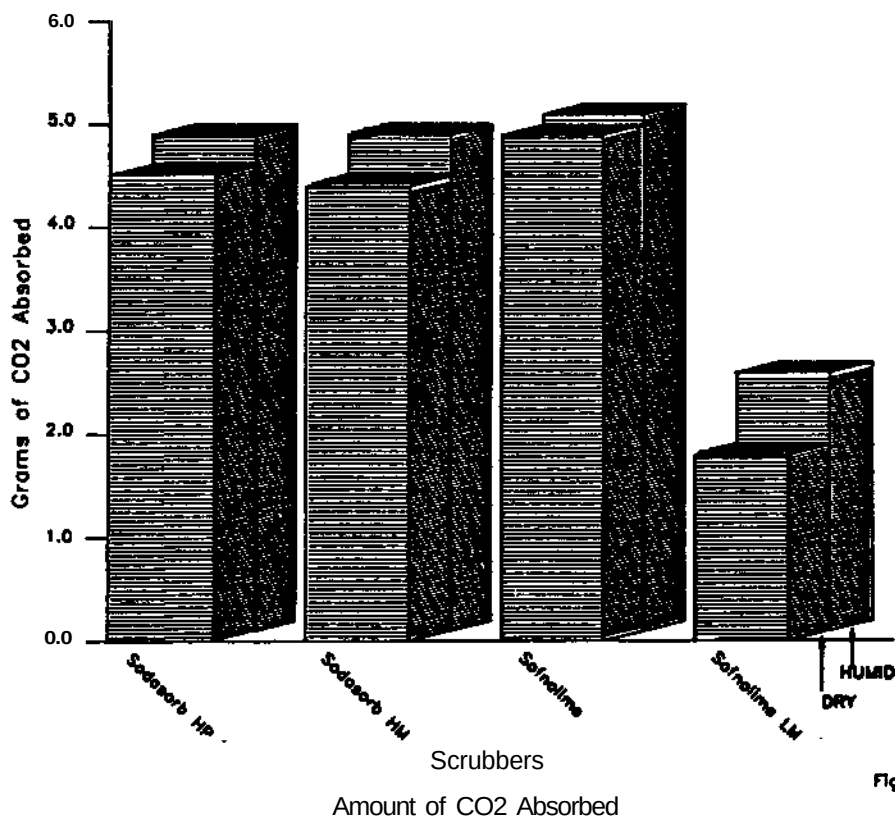


Figure A

initial breakthrough for the 4-8 mesh (4.5 min. to 7.2 min.) and a 50% increase (9.5 min. to 14.2 min.) for the 8-10 mesh when changing from dry to humidified feed gas. However, when using a humidified feed gas no significant increase in the amount of CO_2 absorbed was detected in this testing procedure.

Conclusions

High moisture Sofnolime products absorb more grams of CO_2 per gram of scrubber than the Sodasorb products. Sofnolime high moisture scrubbers were significantly less sensitive to the feed water content than Sodasorb. The rate of absorption is equal for both products at the same mesh size. Smaller mesh sizes increase the rate of absorption for both brands of scrubber. Low moisture Sofnolime has a comparable rate of absorption to the high moisture

scrubbers but has a significantly lower CO_2 capacity. Humidified feed gas increases the amount of CO_2 absorbed by both the Sodasorb products and the Sofnolime LM significantly. Initial CO_2 breakthrough times and the rise to 4% CO_2 increased for the 4-8 mesh size scrubbers when under humidified conditions.

Overall in our test setups, the Sofnolime high moisture scrubbers significantly outperformed the Sodasorb products and are less sensitive to the feed gas condition. No statistical differences were observed between Sodasorb HM and Sodasorb HP products.

Acknowledgment

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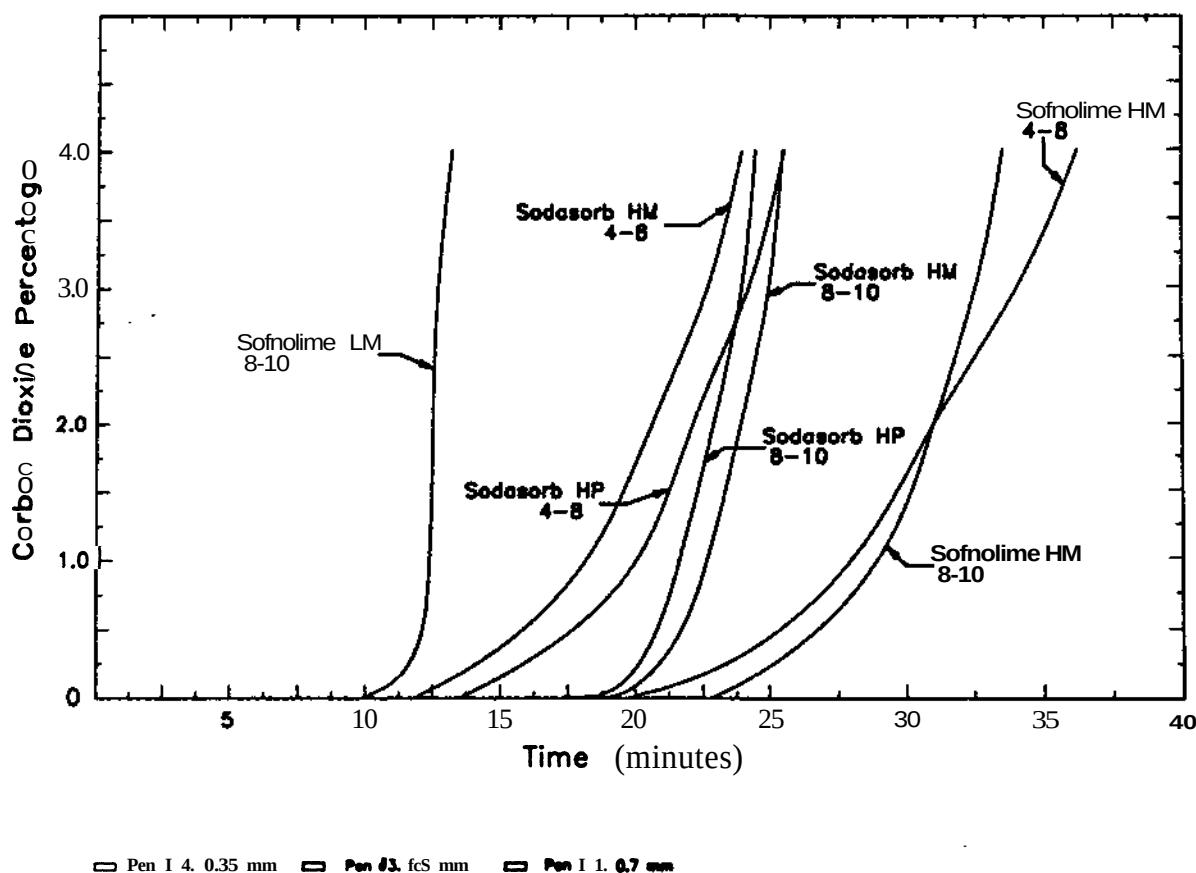


Figure 5
Fast Reaction Results