SODASORB® LF vs AMSORB® PLUS

1.0 INTRODUCTION - Choosing a CO_2 Absorbent: How SODASORB LF and AMSORB Plus Compare on Efficiency, Safety and Disposal*

Selecting a CO_2 absorbent means weighing several practical factors: absorption efficiency (and therefore cost-in-use), safety in low-flow anesthesia practice, reliability of the color indicator and disposal.

SODASORB LF and AMSORB Plus are both formulated to limit the formation of Compound A and carbon monoxide. The aim of this paper is to present the published, peer-reviewed evidence together, set against criteria that matter to anesthetists and procurement teams, alongside our own in-house testing.

Every claim is referenced so it can be independently verified. Where the two products are equivalent, we say so; where the data point to differences, we set out what the studies found and leave the conclusion to the reader.

2.0 CARBON DIOXIDE ABSORPTION EFFICIENCY

In a recent in vitro study by Jiang et. al.[1] SODASORB LF was shown to have ~17% better CO_2 absorption efficiency than AMSORB PLUS when compared on an equal volume basis. These studies were conducted on an ADU anesthesia machine (GE) under identical low flow conditions (TV 500 mL, RR 10 breaths/min, FGF 300 mL/min) using 100 mL of each absorbent four times each. CO_2 absorption efficiency is defined by the authors as the time for inspired CO_2 concentration ($FiCO_2$) to rise to 0.5% (5 torr). In previous published studies SODASORB LF was shown to have better CO_2 absorption efficiency than AMSORB PLUS, ~13% (w/w) by Woehlck et. al.[2] and ~25% to 34% (w/w) by Dahms et. al.[3,4] In direct comparison of commercially available disposable canisters, AMSORB PLUS G-Can versus SODASORB LF ARIA conducted in-house at Molecular Products, Inc.[5] using an S/5 Avance Anesthesia Machine from Datex-Ohmeda, SODASORB LF was shown to have ~48% better CO_2 absorption efficiency than AMSORB PLUS.

3.0 PERMANENT COLOR CHANGE

In a study of four CO_2 absorbents including SODASORB LF and AMSORB PLUS, Yamakage et al.[7] determined that after use in an anesthesia machine and subsequent exposure to air for 16 hours that "the color recognition score of SODASORB LF did not change at all, although the color recognition scores of the other three absorbents significantly decreased ($p < 0.05$)." SODASORB LF was also found to have permanent color change along with Litholyme and AMSORB PLUS in Dahms' study noted above.[4] SODASORB LF will also turn bright lavender when desiccated and will only revert back to white if rehydrated.

4.0 INHIBITION OF SEVOFLURANE DEGRADATION TO COMPOUND A

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An in vivo study by Zhang Xi-zhe and Wu Xin-min[6] determined that SODASORB LF produced no measurable Compound A from Sevoflurane. Another in vivo study by Yamakage et al.[7] also did not detect any Compound A produced by SODASORB LF while a third in vivo study by CAO Jiang-hei et. al.[8] measured only 0.10 ppm Compound A produced. Dahms' in vitro study[3,4] detected 3 ppm Compound A while that of Woehlck et. al.[2] measured only 1.2 ppm peak Compound A produced. Very recent (2019-2022) in vivo and in vitro studies by Ando et. al.[9] demonstrated that $CaCl_2$ containing CO_2 absorbents effectively prevent Compound A production during sevoflurane anesthesia. Since SODASORB LF contains ~2.5% $CaCl_2$ these latest studies support the earlier studies conclusions. Even the 3 ppm Compound A reported in Dahms' study is at the minimum detection limit of ~3.1 ppm for the modern analytical equipment used in Ando's 2019-2022 studies. Finally, Baum and Woehlck[10] in 2003 examined the available data which indicated that Compound A was not a concern in humans.

5.0 INHIBITION OF DESFLURANE DEGRADATION TO CARBON MONOXIDE

Dahms' in vitro study[3,4] referenced above showed that even when desflurane is used in an anesthetic circuit with fully desiccated SODASORB LF no carbon monoxide was produced (0 ppm CO) similar to AMSORB PLUS and Litholyme. Woehlck et. al.[2] measured a total of 9±8 ppm CO average with fully desiccated SODASORB LF and 3±4 ppm CO average using AMSORB PLUS in an anesthetic circuit with desflurane over 15 or more hours. These results were at the minimum detection limit of the instruments used by Woehlck et. al.[2] at that time and account for the large relative error. Sjostrand[20] studied endogenous CO production in humans as early as 1949 and his work suggested endogenous CO was the result of heme degradation. Since then, a significant body of research[21] has refined our understanding of the role of carbon monoxide in the human body and Coburn[22] measured the rate of endogenous CO 0.42±0.07 mL/hr or 7.6 ppm (assuming an average adult total blood volume of 5,500 mL). Given the 15 hour duration of the anesthetic circuit tests, the CO levels arising from the CO_2 absorber are roughly 8% of the endogenous CO from hemoglobin breakdown.

6.0 WASTE DISPOSAL IN CALIFORNIA

For waste to be considered non-hazardous in California it must not be ignitable, reactive, toxic to aquatic species and within a proscribed pH range.[11] SODASORB LF is not ignitable nor is it reactive as defined in 22 CCR § 66261.21&23. SODASORB LF has been tested by methods and in laboratories approved for Toxicity and Corrosivity (pH) by California.

7.0 FATHEAD MINNOW HAZARDOUS WASTE DEFINITIVE BIOASSAY

For a carbon dioxide absorbent to be disposed of in regular (non-hazardous) waste in California the waste must be evaluated for its toxicity to aquatic life, specifically fish.[12] The "Fathead Minnow" bioassay is used to determine the "Lethal Concentration 50," (LC50) of a substance in water that kills 50% of the fish within 96 hours. In order to pass, the 96-hour LC50 must be greater than 500 mg/L. SODASORB LF was used in closed circuit anesthesia circuits using Sevoflurane prior to this bioassay being conducted at a certified laboratory.[13,14] The LC50 of these operating room used SODASORB LF samples were >750 mg/L and are therefore not considered hazardous waste by this bioassay.

8.0 CORROSIVITY TEST SWA846 METHOD 9045D SOIL AND WASTE pH

All carbon dioxide absorbents are solids and are predominantly calcium hydroxide. The only

characteristic of corrosivity applicable to these CO_2 absorbents is §66261.22 (a) (3). A solid waste may be deemed hazardous if, when mixed with an equivalent weight of water, produces a solution having a pH less than or equal to 2 or greater than or equal to 12.5.[15] In a very detailed study calcium hydroxide saturated solutions were determined to have pH 12.45.[16] Even when calcium hydroxide based CO_2 absorbents such as SODASORB LF and AMSORB PLUS are used in anesthetic circuits until $FiCO_2$ ~0.5% there will remain a substantial amount of unreacted $Ca(OH)_2$. When tested at two California approved laboratories[17, 18] following SWA846 9045D the error in the measurement of identical split samples, used in operating rooms with Sevoflurane, ranged from 0.1 to 0.2 pH units and in some cases as much as 0.5 pH. Taking the minimum observed measurement error of ±0.1 into account the pH of a SODASORB LF solution was 12.55±0.1 and AMSORB® PLUS was 12.49 ±0.1. The later result is completely consistent with the pH as reported on the AMSORB® PLUS SDS of ~12.5.[18] Lab to lab and sample to sample variation of the pH measurements from these two independent laboratories puts SODASORB LF within the measurement error of the 12.5 pH boundary.

9.0 CONCLUSIONS

Across the published literature, SODASORB LF and AMSORB Plus share the core safety characteristics expected of a modern absorbent; both produce negligible carbon monoxide from the degradation of anesthetic gas even when desiccated, both retain a permanent color change and both fall within the same disposal and pH profile. Where the evidence consistently separates them is CO_2 absorption efficiency. Independent studies place SODASORB LF between roughly 13% - 34% more efficient[1-4] while internal testing showed up to 48% longer service life in the disposable canisters as sold[5]. This would be expected to result in longer absorbent life and lower cost in-use. Its color indicator also appears more robust to prolonged air exposure, and it turns to bright lavender when desiccated offering an additional visual safeguard. None of this is intended to diminish AMSORB Plus, which remains a well-regarded product. Rather, the evidence taken points to a measurable efficiency advantage for SODASORB LF while matching its peers on the safety measures clinicians' most value.

10.0 REFERENCES

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