

VOLATILE ANESTHETIC RECLAMATION: It's About Time (and Temperature)!

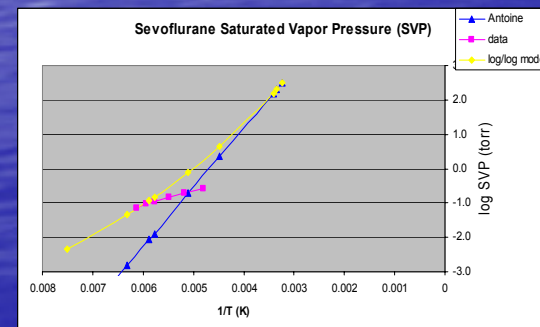
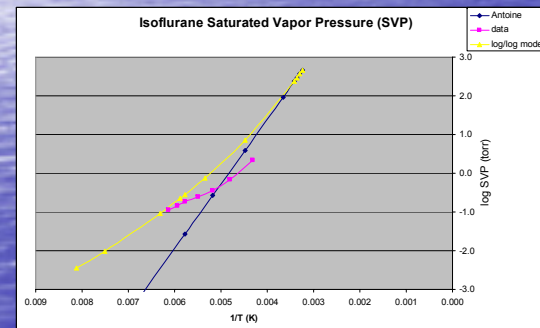
ABSTRACT

Background: In the US alone, approximately 500,000 gallons of volatile halogenated anesthetics (retail value of \$1 billion) are used annually. This entire volume of waste anesthetic gas is vented to the atmosphere after use. The global warming potential of this release is equivalent to over 3,500,000 tons of CO₂. Anesthetics may be captured by adsorption onto carbon or zeolite media, but this technology is expensive and cumbersome. Any vapor may be condensed if the temperature is lowered to where the vapor pressure is greater than its saturated vapor pressure at that temperature and pressure. We postulated that anesthetics may be condensed primarily from a waste stream at cryogenic temperatures.

Methods: We subjected streams of the common volatile anesthetics (isoflurane, desflurane, and sevoflurane) to cryogenic temperatures (-40 to -120 C) in a heat-exchanger/condenser apparatus. Temperatures were measured with a Lake Shore digital thermometer and cryogenic-rated probes. Residual concentrations of anesthetics were determined with a Mura SapphRe trace anesthetic analyzer. Graphs of saturated vapor pressure vs. temperature were constructed. Predicted vapor pressures were generated with logarithmic plots of known vapor pressures near room temperature extrapolated to the cryogenic range. Melting points of the three anesthetics were also determined using a cryostat apparatus cooled with liquid nitrogen.

Results: Plots of saturated vapor pressure vs temperature were in reasonable agreement with predictions from log/log plots (rather than Antoine equations). The saturated vapor pressure of isoflurane was 180 ppm at -100 C.

Discussion: Cryogenic reclamation of volatile anesthetics is possible at temperatures near -100 C. However, present scavenging systems produce an unacceptable (10 to 100-fold) dilution of waste anesthetic concentrations. Modifications of current scavenging technology to reduce dilution would allow this method to produce significant recapture of waste anesthetics for potential purification and reuse. The dual benefit would be the reduction of harmful emissions and the reclamation of useful anesthetics at low cost.



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MELTING POINTS OF VOLATILE ANESTHETICS

SEVOFLURANE	-67 ±1 C
DESFLURANE	-101 ±1 C
ISOFLURANE	-103 ±1 C

FORMULAE FOR SVP PREDICTION

p = saturated vapor pressure
t = temperature (usually degrees Kelvin)
A, B, C, = empiric constants

Antoine equation:

$$\log p = A - B/(t+C)$$

Log/log equation:

$$\log p = A \log t + B$$

DISCUSSION

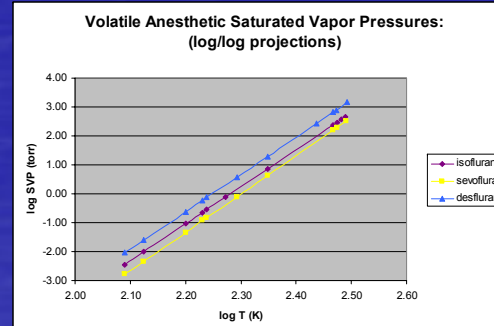
The use of condensation techniques to reclaim volatile anesthetic gases from waste anesthetic gas (WAG) faced two obstacles: 1) the unknown values of melting points and saturated vapor pressures at cryogenic temperatures, and 2) the inefficiencies of attempting condensation of a very dilute gas stream. The average dilution from a WAGD evacuation system is 20-fold (2 lpm fresh gas flow into 40 lpm evacuation suction flow).

The data presented allow for modeling of vapor pressures (VP) of anesthetics at low temperatures and calculation of potential extraction efficiencies as:

$$\text{Efficiency} = (\text{WAG VP} - \text{SVP}) / \text{WAG VP}$$

The recovery rate of undiluted waste anesthetic gas using a condensation temperature of -100C would be approximately 98%, whereas the recovery of gas diluted 20-fold (from 1% to 0.05% would only be 60%.

The feasibility of using condensation to efficiently recover waste anesthetic gases depends upon the use of a modified scavenging system which limits waste gas dilution.



CONCLUSIONS

- 1) At cryogenic temperatures, saturated vapor pressures of volatile anesthetics are better predicted by log/log extrapolations of room temperature data than from Antoine equation extrapolations. This is likely due to the solid-phase transition occurring near -100 C.
- 2) Cryogenic reclamation of volatile anesthetics is feasible if dilution from scavenging systems can be minimized. Optimal temperatures are to be determined by comparing efficiency with cost of cooling.

REFERENCES

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The investigator has significant financial interest in the commercial applications of this data.