 

# In-vitro characterization of novel carbon dioxide absorbents for use in anaesthetic breathing systems

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The circle breathing system of a modern anaesthetic machine may be run in the closed mode and only those amounts of anaesthetic gas or vapour required to produce anaesthesia along with oxygen flow into the anaesthetic circuit are employed. A carbon dioxide absorbent is incorporated within the system and the technique is referred to as Low Flow Anaesthesia (LFA). Certain volatile anaesthetics have been shown to be degraded by strong bases such as NaOH or KOH which are present in conventional soda-lime and baralyme (Bito and Ikeda 1994). Formulation of such absorbents in the absence of strong bases has led to development of a new series of carbon dioxide absorbents (Murray and Fee 1997). In addition to the chemical composition of the absorbent granule, efficient carbon dioxide absorption is dependent on granule moisture content and porosity. It is the moisture within the granules which drives forward the reaction in which $CO_2$ is absorbed. The aim of this study is to formulate a $CO_2$ absorbent granule in the absence of strong bases, which is compatible with anaesthetic circuits currently in use, and will combine a closely controlled moisture content with excellent $CO_2$ absorption properties and hardness profiles.

Calcium hydroxide (Taresh Ltd., NI) and various concentrations of anhydrous calcium chloride (1-10%) (Sigma, Poole, U.K.), anhydrous calcium sulphate (1-10%) (BDH, Poole, U.K.), and PVP (1%) (BASF, Germany) were mixed using a Ufesa commercial mixer. Granulating fluid (5% w/v glycerol) was added in aliquots and the resultant wet mass was passed through a 3.35mm sieve and tray dried at 70°C for 60 – 120 mins. *In-vitro* granule carbon dioxide absorption capacity (sample size 100g) was assessed on a specially adapted anaesthetic breathing circuit. Granule hardness was assessed in terms of % mass loss of granules (20g sample) after 100 revolutions in a friabilator (Copley, Germany).

Table 1: Effect of granule formulation on mass loss and $CO_2$ sorption

| Formulation | Drying time at 70°C (mins) | Mass loss (%) (n=3 ± SD) | In-vitro $CO_2$ sorption (mins) |
|---|---|---|---|
| $Ca(OH)_2$ | 60 | 5.2 ± 0.3 | 180 |
| $Ca(OH)_2$ + 5% $CaSO_4$ | 60 | 6.7 ± 0.3 | 165 |
| $Ca(OH)_2$ + 1% $CaSO_4$ | 60 | 3.0 ± 0.4 | 120 |
| $Ca(OH)_2$ + 1% $CaCl_2$ | 60 | 4.7 ± 0.3 | 180 |
| $Ca(OH)_2$ + 1% $CaSO_4$ + 1% PVP | 90 | 2.5 ± 0.5 | 120 |
| $Ca(OH)_2$ + 1% $CaSO_4$ + 1% $CaCl_2$ | 90 | 5.0 ± 0.9 | 165 |
| conventional soda-lime | - | 1.7 ± 0.3 | 240 |

Granulating fluid consisting of a 5% (w/v) solution of glycerol in water produced granules from $Ca(OH)_2$, in the absence of either NaOH or KOH, which showed an acceptable $CO_2$ absorption capacity but with a poor hardness profile. Addition of increasing concentrations of $CaSO_4$, caused an increase in % mass loss. This was related to increased retention of moisture within the granules. Incorporation of various combinations of selected excipients resulted in improved granule hardness properties, offset however by reduced, yet in some cases acceptable, $CO_2$ absorption capacity (Table 1). Work is currently ongoing to further optimise a final formulation which may involve a compromise between granule hardness and gas absorption capacity.

Bito, H. and Ikeda, K. (1994) Anesthesiology 80: 71-76

Murray, J.M. and Fee, J.P.H. (1997) ALFA Symposium 17 - 21