Biological air purification for air quality control in manned space stations and other closed environments

in cooperation with:

Introduction

Long term manned space craft missions requires recycling of raw materials and environmental quality assurance. Indoor air quality control is essential as astronaut activities and equipment onboard are sources of air contamination.

A wide range of volatile organic contaminants (VOCs) has been observed during manned space craft missions of which most of them are good biodegradable. Therefore biological air purification is an interesting alternative for the current systems used. These systems consist of activated carbon and catalytic oxidation, which requires fuel and frequent exchange of the active carbon.

A biological air purification system for closed environments like manned space crafts needs to meet several criteria like:

- removal of contaminants at extreme low concentrations;
- combined removal of a wide range of contaminants;
- its operation should be stable and robust over long periods of time (months to years);
- its configuration should be small in volume and low in weight;
- no contact between bacteria and astronauts.

Method

A biological air filter (BAF) which meets these criteria has been designed and tested to purify air contaminants from different sources. The BAF is composed of a membrane module, containing bacteria and a liquid nutrient solution. The gas phase is separated from the bacteria in the liquid phase by the membrane (figure 1). Based on the identification of main contaminants to be removed, a selection was made for a mixed bacterial population.

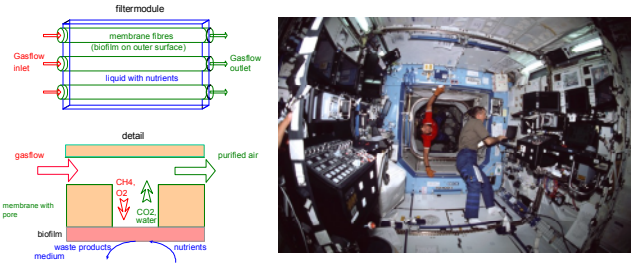

Figure 1 : Principle of membrane biofiltration (left) and closed environment at manned space station ISS (right)

Three different sources of contaminants were used; a mice cage (model system for animal housing in space), sealed plant growth chambers and a pilot reactor of compartment I of MELISSA (Micro-Ecological Life Support System Alternative). This is an advanced life support system for recycling of solid and liquid waste from crew in future manned space crafts (Lasseur *et al.*, 1998).

Results

The biological air purification system (BAF) can remove the low inlet concentrations at removal capacities between 2 and 26 g VOC/m^3 BAF/h at retention times of 8 to 23 seconds. Even at extreme low concentrations (a few ug/m^3) good biodegradation efficiencies are observed. The system is flexible towards the introduction of new contaminants and starvation and shows excellent operational stability for periods up to one year (Eckhard *et al.*, 1999; van der Waarde *et al.*, 2001). The BAF reduces the odour content of the air from mice cage by 80-90% and ammonia by 75-95% with no decrease in removal at the highest load tested (figure 2). For MELISSA compartment I, an overall odour removal percentage of 94% has been achieved.

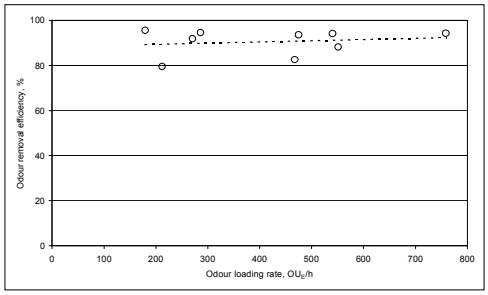

Figure 2: Effect of BAF odour loading rate on removal efficiency of air from a mice keeping system

Conclusions

Different test results show that the developed biological air filtration system (BAF) is a suitable technology to purify contaminated air from the different sources in future manned space crafts.
The system could also be used for future indoor air quality control in modern buildings to prevent symptoms generally referred to as 'Sick Building Syndrome' and 'Building Related Illness'.

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