

SENSITIVITY SCREENING OF RADISH SEEDLINGS TO SPACECRAFT VOCs

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Atmospheric contaminants in spacecraft can affect the performance of plant-based life support systems for long duration space missions. NASA has established Spacecraft Maximum Allowable Concentration (SMAC) guidelines for crew exposure to air pollutants commonly found in spacecrafts and the International Space Station. However, NASA has not established similar guidelines for plant systems. An automated volatile organic compound (VOC) system was developed to allow bioactivity screening of compounds on plant growth.

A series of experiments were conducted to determine the radish seedling threshold values to four alcohols currently present in the International Space Station (ethanol, isopropyl, tert-butyl alcohol, and methanol). Growth after five days of chronic exposure to the alcohol on the radish seedling (*Raphanus sativus* L., cv. Cherry Bomb Hybrid II) at a concentration of 0, 50, 100, 175, 250 and 500ppm for each alcohol was used to establish preliminary threshold values. The SMAC values for ethanol, methanol, tert-butyl alcohol, isopropyl alcohol are 1000ppm, 6.7ppm, 39.6ppm and 61ppm, respectively.

Results show a general response-pattern for the four alcohol exposures at threshold responses of 10%, 50% and 90% of the total biomass of the plant (Table 1). At concentrations of 50-115ppm, a slight reduction (~10%) in seedling growth was observed. When the alcohols exposure was increased at 120-250ppm, there was a reduction of seedling growth by ~50% and finally, seeds did not germinate in the presence of alcohol concentrations above 250ppm. The results indicated a very different sensitivity of alcohols on humans than on plants. Ethanol is the only alcohol to be bioactive (SMAC= 1000 ppm), while isopropyl, tert-butyl alcohol, and methanol bioactivity begin at levels quite high above their human SMAC levels (60, 40, 6.7ppm respectively).

Table 1: Threshold values of isopropanol, tert-butanol, ethanol and methanol on length of radish seedlings.

Compound	SMAC (ppm)	T ₁₀ (ppm)	T ₅₀ (ppm)	T ₉₀ (ppm)
Isopropanol	61	115	245	450
Tert-butanol	40	80	120	375
Ethanol	1000	60	235	450
Methanol	6.7	50	285	460

T₁₀ = 10% reduction in seedling length; T₅₀ = 50% reduction in seedling length; T₉₀ = 90% reduction in seedling length; SMAC = Spacecraft Maximum Allowable Concentration.

These studies indicate that existing guidelines for VOC contamination, such as SMAC established for humans are not suitable for use in establishing bioactivity thresholds for plants. The seedling VOC bioassay provides a rapid screening tool to establish the biological threshold of several VOCs and to identify compounds must be monitored and/or filtered during long duration space missions.

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