Abstract:
On the STS-135 Space Shuttle mission, launched July 8, 2011, a forward osmosis bag (FOB) study will be conducted at NASA Ames this summer. The ground truth testing is being conducted for results comparisons.

The FOB technology is derived from a commercial product, the X-Pack water filter. It is expected that the current system will retrieve 60% of the water from the grey water source. This concept could be used in space to provide drinking water in emergency situations.

Background:
Forward osmosis operates by utilizing an established concentration gradient across a semi-permeable membrane to move water molecules from one side of the membrane to the other. This concept is exploited to harvest drinking water from grey water sources such as urine, sea water, or vehicle water.

In this experiment, potassium chloride (KCl) dissolved in water is used to simulate grey water. The KCl water is inserted into the FOB on one side of the membrane and highly concentrated sugar water is inserted on the other. The high concentration of sugar solutes creates a gradient that drives water molecules to pass through the membrane and enter the other side.

The membrane properties prevent the solutes from diffusing, allowing only the water molecules to be harvested from the solution. The FOB efficiency is tested by use of a fluorescent dye marker in the sugar water side of the bag. The concentration of the dye decreases as more water diffuses across the membrane. The concentration of the dye is measured using a fluorometer and comparing intensity readings to intensity values of known concentrations.

Creating Solutions:
A FEED solution composed of sugar water and fluorescent dye is used to establish a strong concentration gradient and pull water from the other solution. This solution becomes more dilute as the experiment continues.

A DRAW solution composed of salt water and blue dye is used to simulate grey water and provide the source for water to be pulled from.

Performing Experiment

1. Lay bag flat on the floor and wait 6 hours before sampling.
2. Take a 50 ml sample from the DRAW side and measure remaining liquid in both FEED and DRAW sides.
3. Use a fluorometer to measure intensity of dye in the sample and relate to amount of water recovered using calibration curve.
4. Insert FEED and DRAW bag into the membrane of the FOB using syringes.

Data Analysis

The intensity reading is put into the equation of the line from the calibration curve as the variable ‘Y’. The solution is solved to find the ‘X’ variable of the concentration.

\[ Y = (1 \times 10^{-9})X + (1 \times 10^{-7}) \]

The concentration is an indication of how diluted the solution has become. In other words, the concentration tells us how much water from the FEED side entered the DRAW solution side of the membrane.

The fluorometer measures intensity in counts per second (cps).

The photo above is of the International Space Station. This is where Atlantis was returning to earth from when the space experiment was conducted.

Analysis

The data from volume measurements of recovered fluid suggests that the FOB is able to recover between 56% and 58% of the water. The data from the fluorescent dye measurements of recovered fluid suggest that the FOB is able to recover between 66% and 69% of the water.

Based on these experiments it seems that this may be a viable emergency water source. But, if this is to be used as a long term source of drinking water, a more efficient membrane may need to be tested.

Conclusions

Astronauts aboard Atlantis Space Shuttle conducted the same experiment on the last day of their mission before returning home to earth.

References:

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