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University of Rhode Island
Graduate School of Oceanography
215 South Ferry Rd,
Narragansett, RI 02882
401.874.6826
www.unols.org

Finding and Recommendations for the use of Stable Isotopes (^{15}N and ^{13}C) within the ships of the US Academic Research Fleet
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Introduction
An isotope of an atom is one that has the same number of protons, but with different numbers of neutrons. Many atoms have both Stable isotopes and Radioisotopes. Stable isotopes have stable nuclei and do not emit radiation while radioisotopes have unstable nuclei and emit radiation. Some scientists conduct experiments that use solutions enhanced with radioisotopes, some conduct experiments using solutions enhanced with stable isotopes while others, natural abundance scientists, study the concentration of these isotopes in nature (esp. ^{14}C and ^{3}H). Radioisotopes are sometimes referred to as rads.

Enhanced radioisotope work is confined to Radioisotope Vans (radvans) for two reasons. First, due to the radiation emitted by the radioisotopes, at certain concentrations enhanced radioisotope solutions can present a Health and Safety risk. To minimize these risks, scientists who work with radioisotopes go through specific radioisotope safety training and access to the radvans is limited to those who have received training. In addition to training, radioisotope users are required to take every precaution possible to minimize risk of exposure to themselves and non-users onboard. Second, radioisotopes occur in nature at extremely low levels (parts per trillion – 1 sand grain in 5 truckloads of sand). Radioisotope solutions used in enhanced radioisotope experiments are 10 to 12 orders of magnitude more concentrated than natural levels. The difference is so great that even an inadvertent spill of a small fraction of a drop of spiked radioisotope solution could decimate natural abundance work. Thus, the radioisotope van is used in an effort to contain both *gross* contamination, which could create a Health and Safety problem, and also *micro*-contamination, which could destroy natural abundance work.

What about enhanced stable isotope solutions? As stated above, stable isotopes have stable nucleus and do not emit radiation. For this reason, stable isotopes do not present a Health and Safety risk. The question that remains is if stable isotopes present a micro-contamination problem for natural abundance work. The UNOLS office has been asked to assist in investigating this issue by answering the following questions: 1) Do enhanced stable isotopes (esp. ^{15}N and ^{13}C) present a micro-contamination problem for natural abundance work? 2) Should this work be confined to a laboratory van?

More details are listed below but after extensive discussions with a range of scientists who study stable isotopes and their ratios in the natural environment it was concluded that, with proper precautions, it is not necessary to confine enhanced ^{15}N and ^{13}C stable isotope experiments in a laboratory van.

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Concerns/Items Discussed

1. *Are stable isotopes a Health and Safety concern?* Stable isotopes are not a Health and Safety concern.

2. *Could contamination from labeled stable isotope solutions make a ship unusable for scientists studying the natural abundance of these same stable isotopes?*
After discussion with a variety of natural abundance scientists, it was concluded that, unlike ^{14}C where the enhanced radioisotope solution concentrations are highly anomalous from natural concentrations, the concentration of the stable isotopes in the enhanced stable isotopes solutions are similar to the natural environmental concentrations. Thus, micro-contamination from labeled stock isotopes would not have the devastating effects on natural abundance work that radioisotope contamination would have. That said it is still prudent for enhanced stable isotope users to take proper precautions to minimize/eliminate contamination (see Recommendations below).

3. *Stable isotopes could be contaminated with radioisotopes in the manufacturing process.* Some investigators have expressed concern that this sort of contamination is possible and may have happened. No direct evidence of this has been found. Investigations are ongoing. The concern mostly centers on ^{14}C contamination through ^{13}C use.

   Theoretically, contamination could occur either through cross-contamination (in the case where both stable and radioisotopes are manufactured in the same facility) or through the process of enhancing the stable isotopes. This topic was discussed at length and it is felt that the likelihood of radioisotope contamination is miniscule if at all possible. First, with all of the regulations and expense around radioisotope enrichment, it is very unlikely that a manufacturer would/could add radioisotopes to a stable isotope solution. Second, ^{13}C isotope enrichment uses a carbon source isolated from old geologic sources that have no appreciable ^{14}C. Finally, the ^{13}C enrichment is very small compared to the process used to make ^{14}C enriched compounds. So in the unlikely case where there is ^{14}C present, its enrichment would not be significant.

4. *Equipment (glassware, etc.) that is used with labeled stable isotopes may have been previously used with radioisotopes and could still contain trace amounts of radioisotope (esp. ^{14}C).*
This type of cross-contamination would be most common in a case where the PI works with both labeled stable isotopes and radioisotopes. Precautions must be taken to ensure that the labeled stable isotopes, especially ^{13}C, are not contaminated with radioisotopes.

5. *If the labeled stable isotope users were forced to work in a radioisotope van, is there concern that these users could inadvertently track radioisotopes into the skin of the ship.*

UNIVERSITY OF RHODE ISLAND
GRADUATE SCHOOL OF OCEANOGRAPHY
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WWW.UNOLS.ORG

Labeled stable isotope users may not have had the same training as radioisotope users and may not understand the proper precautions necessary to avoid contamination and keep radioisotopes within the van. This could lead to inadvertent contamination of latent radioisotopes from the van to the skin of the ship.

Conclusions

If labeled stable isotope users implement proper precautions, the use of ^{15}N and ^{13}C in the skin of the ship should not present contamination issues for natural abundance science. The case for ^{13}C is a bit trickier due to the concerns of ^{14}C contamination. Taking proper precautions to prevent ^{14}C contamination will minimize this risk.

Recommendations for ^{15}N and ^{13}C use within the ship

- Labeled stable isotope users should practice good chemical hygiene habits as recommended/required by their home Institution. Good practices should include but not be limited to:
  - Labeled stable isotope work is conducted in a contained area
  - Gloves used with labeled stable isotopes are removed prior to leaving the work area
  - Labeled stable isotope spike is kept away from common use equipment such as niskins
  - Spills of any sort are reported immediately
  - Stock solutions should have secondary containment
- The stable isotope work area should be thoroughly cleaned (dilute acid solution) after use.
- The ship should be SWAB'ed after the last use of radioisotopes and then again after the labeled stable isotope work.
- As an added precaution, the PI should contact the stable isotope manufacturer to discuss the possibility of radioisotopic contamination.