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Supporting Information Available.

Derivation for the $^{17}$O correction for mass independent $\delta^{15}$N calculations of nitrous oxide.

The $^{17}$O correction for $\delta^{15}$N can be derived as follows. Starting with the definition of $\delta^{15}$N:

$$\delta^{15}N = \left( \frac{^{15}R_S - ^{15}R_R}{^{15}R_R} \right) \times 1000$$

where $^{15}R_S$ is the ratio $^{15}N/^{14}N$ of the sample and $^{15}R_R$ is the ratio $^{15}N/^{14}N$ of the reference.

Since the mass 45 signal is a combination of both $^{15}N$ and $^{17}O$ from N$_2$O, the calculated $\delta^{45}$N$_2$O value will also be a combination of the two, and $^{15}R_S$ cannot be measured directly. Therefore the above equation needs to be expressed in terms that are measured directly or known from previous experiments. Terms that are known are the $^{17}R$ (assuming mass dependent fractionation) and $^{15}R$ of the standard. $\delta^{45}$N$_2$O is measured directly, and so is $\delta^{18}$O. Fortunately in most cases mass dependent fractionation dominates, and the assumption that $\delta^{17}$O = 0.52 $\delta^{18}$O is valid. If the above equation is transformed into these terms, the $\delta^{15}$N of the sample can be found.

The mass spectrometer is tuned to measure m/z 44, 45, and 46. Mass 44 consists of $^{14}N^{14}N^{16}O$ ions. Mass 45 consists primarily of $^{15}N^{14}N^{16}O$, $^{14}N^{15}N^{16}O$, and $^{14}N^{14}N^{17}O$ ions. Mass 46 consists primarily of $^{14}N^{14}N^{18}O$ ions. Next we solve for $^{45}R$ and $^{46}R$ in terms of $^{15}R$, $^{17}R$, and $^{18}R$:

$$^{45}R = \frac{m/z45}{m/z44} = \frac{^{15}N^{14}N^{16}O + ^{14}N^{15}N^{16}O + ^{14}N^{14}N^{17}O}{^{14}N^{14}N^{16}O} = ^{15}R + ^{15}R + ^{17}R = 2^{15}R + ^{17}R$$
\[ \delta^{15}N = \frac{^{15}R - ^{15}R}{^{15}R} \times 1000 \]

Through substitution and arrangement, we can obtain a \( \delta^{15}N \) equation in a more useful form:

\[ \frac{^{14}N^{14}N^{18}O}{^{14}N^{16}N^{16}O} = ^{18}R \]

\[ ^{15}R = \frac{^{45}R - ^{17}R}{2} \]

\[ ^{17}R = ^{45}R - ^{2}^{15}R \]

\[ \delta^{15}N = \left( \frac{^{15}R - ^{15}R}{^{15}R} \right) \times 1000 = \left[ \left( \frac{^{45}R - ^{17}R}{2^{15}R} \right) - \left( \frac{^{45}R - ^{17}R}{2^{15}R} \right) \right] \times 1000 \]

\[ = \left( \frac{^{45}R - ^{45}R}{2^{15}R} \right) \times 1000 \]

\[ = \left( \frac{^{45}R - ^{45}R}{2^{15}R} \right) \times 1000 \]

\[ = \left( \frac{^{17}R - ^{17}R}{2^{15}R} \right) \times 1000 \]

\[ = \left( \frac{^{17}R - ^{17}R}{2^{15}R} \right) \delta^{15}N - \left( \frac{^{17}R - ^{17}R}{2^{15}R} \right) \delta^{17}O \]

\[ = \left( \frac{^{17}R + ^{2}^{15}R}{2^{15}R} \right) \delta^{15}N - \left( \frac{^{17}R - ^{17}R}{2^{15}R} \right) \delta^{17}O \]

\[ \delta^{15}N = \left( \frac{^{17}R}{2^{15}R} + 1 \right) \delta^{15}N - \left( \frac{^{17}R}{2^{15}R} \right) 0.52 \delta^{46}N^{2}O \]

which is the equation used in all calculations of \( \delta^{15}N \) of \( N_2O \).