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# Exploring the use of $^{17}O$-excess in $CO_2$ for estimating mesophyll conductance of $C_3$ and $C_4$ plants

**THOMAS RÖCKMANN**[1], GETACHEW AGMUAS ADNEW[1], THIJS PONS[2], GERBRAND KOREN[2] AND WOUTER PETERS[3]

[1]Institute for Marine and Atmospheric Research Utrecht, Utrecht University
[2]Utrecht University
[3]Wageningen University

Presenting Author: t.roeckmann@uu.nl

Mesophyll conductance to $CO_2$ ($g_m$) is an important parameter controlling plant photosynthesis and water use efficiency, and vegetation-atmosphere $CO_2$ exchange. Here we demonstrate the potential to estimate $g_m$ from measurements of $\delta^{17}O$ of $CO_2$, where $\delta^{17}O$ quantifies the $^{17}O$-excess compared to what is expected from the $^{18}O$ content of $CO_2$ according to mass-dependent isotope fractionation. The $g_m$ calculations are applied to measurements of $\delta^{18}O$ and $\delta^{17}O$ in leaf cuvette gas exchange measurement with sunflower, ivy, and maize, using normal and slightly $^{17}O$-enriched $CO_2$. We show that $g_{m\delta17}$ estimates can complement and potentially improve the $g_{m18}$ estimates in settings where the $\delta^{18}O$ leaf water varies strongly throughout the day, affecting the $\delta^{18}O$ ($CO_2$) difference between the intercellular air space and the $CO_2$-$H_2O$ exchange site. This is because $\delta^{17}O$ is less sensitive to the unknown isotope fractionation during evapotranspiration of leaf water than $\delta^{18}O$ because the isotope fractionation processes involved are all mass-dependent. The main limitation to the use of $g_{m\delta17}$ is the uncertainty in the measurement of the very small signals in $\delta^{17}O$. In general, the precision of a $g_m$ determination with oxygen isotope techniques decreases when the isotopic difference between $CO_2$ in the intercellular air space and at the $CO_2$-$H_2O$ oxygen exchange site becomes very small. In leaf cuvette experiments this limitation can partially be overcome by using $^{17}O$- or $^{18}O$-enriched $CO_2$. However, both $g_{m18}$ and $g_{m\delta17}$ are not good tracers for plant species with very high mesophyll conductance, because in this case the oxygen isotope gradient between the $CO_2$-$H_2O$ exchange site and the intercellular air space is very small. Both $g_m$ estimates are sensitive to the assigned degree of equilibration between $CO_2$ and water ($\theta_{eq}$).