Looking at methane sources in the right light

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A methane source in the sunlight: Plants form the greenhouse gas under UV radiation, which is also part of sunlight. A large proportion of the gas is released from pectin - a bio-polymer from which the supporting structures of flowers and leaves is made. Image: Frank Keppler / MPI for Chemistry

Plants store one greenhouse gas, but emit another. Whereas they bind carbon dioxide, they release methane - albeit in small quantities. This has now been confirmed by scientists from the Max Planck Institute for Chemistry, the University of Utrecht and the Agri-Food and Biosciences Institute in Belfast.

In two new studies, they also established that some of the greenhouse gas comes from pectin, a substance that plants use to build their supporting structure. The studies went on to reveal that UV light boosts methane production - which also explains why some researchers were unable to

identify any plant-based methane: they were growing plants under light sources that did not radiate UV. (*New Phytologist*, May 9, 2008; *Biogeosciences* in press)

Two years ago, their announcement caused a stir: Frank Keppler and his colleagues at the Max Planck Institute for Nuclear Physics in Heidelberg had observed, for the first time, that plants release methane - into the air: meaning under aerobic conditions, under which bacteria produce no methane, allowing it, for example, to bubble up out of bogs and marshes. This study indicated that plants contribute a substantial proportion of the methane in the atmosphere.

Strong controversy broke out not only surrounding the global significance of these plant-based methane emissions. Some researchers even doubted whether plants release this greenhouse gas at all, which is 25 times more damaging to the environment than carbon dioxide. Now however, Frank Keppler who in the meantime conducts research at the Max Planck Institute for Chemistry, and his colleagues have produced more evidence from detailed experiments: these have shown that plants do indeed produce methane - and in especially high quantities when they are irradiated with UV.

In a recent comment, Tom Dueck, a scientist at the University of Wageningen in the Netherlands, acknowledged the validity of Keppler's new findings. Something that Keppler is particularly pleased about. Dueck had cast strong doubts on his results, not least because he and his colleagues were unable to reproduce them. However, they were growing plants in greenhouses under artificial light that did not emit UV.

Frank Keppler and his colleagues, some of who are now working at the University of Utrecht, examined both dry and fresh material from more than 20 different plants. "This time, we deliberately used only plant parts like leaves, for example, because it is possible that there are processes

taking place in living plants which can distort the results," says Keppler. The researchers irradiated the plants with UV light in one series of experiments. At the same time, in another, they heated the plants to 100º Celsius and in a third, examined the plants at temperatures ranging from 20 to 100º Celsius.

In the process, they established that not all plants emit the same amount of methane. However, the more energetic the light shone on the specimens, the more greenhouse gas they released. Production reached even higher rates when the temperature was simultaneously increased. Without UV radiation and at an ambient temperature of 22º Celsius, the plants released from 100 to 1000 times less methane.

From 80º Celsius, the emission rates rose to values comparable to those under UV light. Furthermore, heat releases increasingly less methane when the researchers heat and cool a specimen several times in succession. However, if the scientists switch on a UV lamp positioned over a specimen several times, it always releases the same amount of methane. "UV light obviously uses a different reaction mechanism than heat to release the gas," says Keppler.

One component from which UV light creates methane in a photochemical process is pectin - a polysaccharide that many plants use as a structural material. It contains methoxyl groups in which there are already the rudiments of the methane chemical structure. The scientists had already found indications that this is where the methane might come in their studies from two years ago. Now, in another study using isotope analysis, the researchers have proven unequivocally that this mechanism exists. They replaced the hydrogen atoms in this group with deuterium - heavy hydrogen - and subsequently found the deuterium in the methane again.

However, not all methane can be formed in this way because in the

experiments with UV light, methane also originates without deuterium. The fact that cellulose also creates methane under UV light, albeit much less than pectin, also fits this theory. Unlike pectin, cellulose does not have methoxyl groups. "We have no idea at the moment what this alternative mechanism might look like," says Frank Keppler. "Precisely because, up to now, we have only understood some of the processes that underlie methane emissions from plants, it is difficult to estimate the extent on a global scale."

Publications:

Frank Keppler, John T.G. Hamilton, W. Colin McRoberts, Ivan Vigano, Marc Braß and Thomas Röckmann, Methoxyl groups of plant pectin as a precursor of atmospheric methane: evidence from deuterium labelling studies, *New Phytologist*, May 9, 2008

Ivan Vigano, Huib van Weelden, Rupert Holzinger, Frank Keppler, Andy McLeod and Thomas Röckmann, Effect of UV-radiation and temperature on the emission methane from plant biomass and structural components, *Biogeosciences* in press

Source: Max Planck Institute for Chemistry