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Making the number one climate threat less dangerous

Burning cars, drowning polar bears, and the extinction of trees; that's how some of us might imagine the results of climate change. To keep the cars from burning and the bears from drowning, fossil fuels have to be replaced in the near future. A promising alternative are bio-fuels, which contain a lot of methane. This, unfortunately, is a potent greenhouse gas which is why it needs to be removed from exhaust processes by being processed further. The most common processing method is oxidation, meaning turning methane and oxygen into water and carbon dioxide. This reaction, however, is like trying to climb over a mountain. It needs some help, so-called *catalysts*, to take place. The catalyst acts like a tunnel, it lowers the energy needed to make the reaction occur. To learn more about how to build the optimal tunnel for the processing of methane, we need to learn more about the reaction itself. It can be studied using X-rays, and just like at the doctor's, the resulting image can tell us what is going on. With this method, it is thus possible to follow each step of the reaction which gives additional information about the system. Therefore, we can learn a lot about the methane oxidation reaction.

During the studies in this thesis, we wanted to find out whether certain catalyst surface phases preferably process methane in one of the following ways. If there is a lot of oxygen present in the vicinity of methane sticking to the surface, carbon dioxide and water will be produced. If there is less oxygen available, carbon monoxide and water will be the products of the reaction. And finally, if no oxygen is used, a layer of atomic carbon will form at the surface.

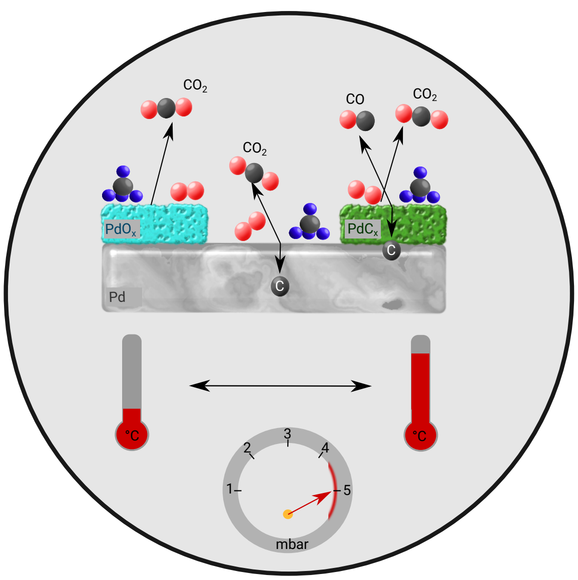

Figure 1: Products of methane oxidation for Pd surface phases (water is not shown).

As these various surface phases do not just appear, we placed the palladium catalyst in a gas environment with a certain ratio of oxygen and methane. Then, we heated the metal up and cooled it down again between 350 °C and 585 °C, several times. At these different temperatures, and with a carefully selected gas composition surrounding the catalyst, the three desired surface phases were formed subsequently, that is a metallic, a carbon covered, and an oxygen-covered surface.

With the X-rays, we then looked at the reaction and could indeed find out, that a surface covered in oxygen will only allow methane to produce carbon dioxide and water while the carbon-covered surface also allows the

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formation of carbon monoxide and an additional carbon layer at the surface. The metallic surface seems to allow both, the formation of carbon dioxide and a carbon layer at the surface, however, no formation of carbon monoxide was observed. This is schematically displayed in Figure 1.

In conclusion, both, the results obtained as well as the applied technique are very promising. The result, that a surface covered in oxygen will only produce carbon dioxide and water when processing methane, can be used in car exhausts for instance, when the formation of the toxic carbon monoxide needs to be suppressed. The temperature-ramping technique is a very handy way to conduct experiments in a reproducible and reliable manner. This is very important for research in general and contains, therefore, a vast range of possible applications. Overall, the knowledge obtained during this work will be applicable in the reformation of catalysts in industrial processing. That makes it possible to more efficiently remove methane from exhaust gas which will eventually help to tackle climate change.

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