**OXO PALLADATION**

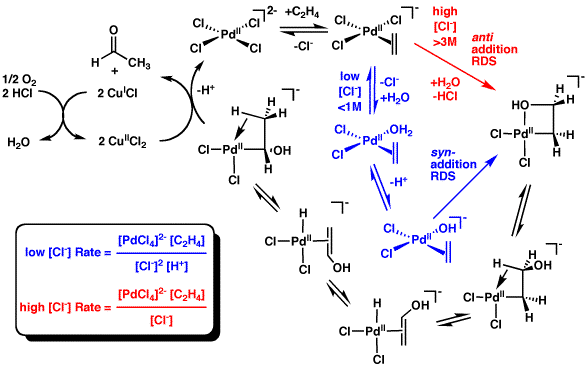
The **Wacker process** or the **Hoechst-Wacker process** (named after the chemical companies of the same name) originally referred to the oxidation of [ethylene](http://en.wikipedia.org/wiki/Ethylene) to [acetaldehyde](http://en.wikipedia.org/wiki/Acetaldehyde) by [oxygen](http://en.wikipedia.org/wiki/Oxygen) in water in the presence of a tetrachloropalladate [catalyst](http://en.wikipedia.org/wiki/Catalysis).[[1]](http://en.wikipedia.org/wiki/Wacker_process#cite_note-0) The same basic reaction is currently used to produce [aldehydes](http://en.wikipedia.org/wiki/Aldehydes) and [ketones](http://en.wikipedia.org/wiki/Ketones) from a number of [alkenes](http://en.wikipedia.org/wiki/Alkenes) with the [Monsanto process](http://en.wikipedia.org/wiki/Monsanto_process) for producing [acetic acid](http://en.wikipedia.org/wiki/Acetic_acid). This [chemical reaction](http://en.wikipedia.org/wiki/Chemical_reaction), a German invention, was the first [organometallic](http://en.wikipedia.org/wiki/Organometallic) and [organopalladium](http://en.wikipedia.org/wiki/Organopalladium) reaction applied on an industrial scale. The Wacker process is similar to [hydroformylation](http://en.wikipedia.org/wiki/Hydroformylation), which is also an industrial process and also leads to [aldehyde](http://en.wikipedia.org/wiki/Aldehyde) compounds. The differences are that hydroformylation promotes chain extension, and uses a [rhodium](http://en.wikipedia.org/wiki/Rhodium)-based catalyst system. The Wacker process is an example of [homogeneous catalysis](http://en.wikipedia.org/wiki/Homogeneous_catalysis). The palladium complex with ethylene is reminiscent of [Zeise's salt](http://en.wikipedia.org/wiki/Zeise%27s_salt), K[PtCl3(C2H4)] which is a [heterogeneous catalyst](http://en.wikipedia.org/wiki/Heterogeneous_catalysis)

## History

The development of the chemical process now known as the Wacker process began in 1956 at [Wacker Chemie](http://en.wikipedia.org/wiki/Wacker_Chemie).[[2]](http://en.wikipedia.org/wiki/Wacker_process#cite_note-1) At the time, many simple aliphatic compounds were produced from [acetylene](http://en.wikipedia.org/wiki/Acetylene) (as [calcium carbide](http://en.wikipedia.org/wiki/Calcium_carbide)) but the construction of a new oil refinery in [Cologne](http://en.wikipedia.org/wiki/Cologne) by [Esso](http://en.wikipedia.org/wiki/Esso) close to a Wacker site, combined with the realization that [ethylene](http://en.wikipedia.org/wiki/Ethylene) would be a cheaper raw-material prompted Wacker to investigate its potential uses. As part of the ensuing research effort, a reaction of ethylene and oxygen over [palladium on carbon](http://en.wikipedia.org/wiki/Palladium_on_carbon) in a quest for [ethylene oxide](http://en.wikipedia.org/wiki/Ethylene_oxide) unexpectedly gave evidence for the formation of acetaldehyde (simply based on smell). More research into this ethylene to acetaldehyde conversion resulted in 1957 in a gas-phase reaction patent using a heterogeneous catalyst.[[3]](http://en.wikipedia.org/wiki/Wacker_process#cite_note-2) In the meanwhile [Hoechst AG](http://en.wikipedia.org/wiki/Hoechst_AG) joined the race and after a patent filing forced Wacker into a partnership called **Aldehyd GmbH**. The heterogeneous process ultimately failed due to catalyst inactivation and was replaced by the water-based homogeneous system for which a pilot plant was operationally in 1958. Problems with the aggressive catalyst solution were solved by adopting [titanium](http://en.wikipedia.org/wiki/Titanium) (newly available for industrial use) as construction material for reactors and pumps. Production plants went into operation in 1960.

## Reaction mechanism

The [reaction mechanism](http://en.wikipedia.org/wiki/Reaction_mechanism) for the industrial Wacker process (olefin oxidation via palladium(II) chloride) has received significant attention for several decades, and parts of it are still a contentious subject. A modern formulation is described below:

[](http://en.wikipedia.org/wiki/File:WackerMechWiki3.gif)

The [catalytic cycle](http://en.wikipedia.org/wiki/Catalytic_cycle) can also be described as follows:

[PdCl4]2 − + C2H4 + H2O → CH3CHO + Pd + 2 HCl + 2 Cl−

Pd + 2 CuCl2 + 2 Cl − → [PdCl4]2− + 2 CuCl

2 CuCl + ½ O2 + 2 HCl → 2 CuCl2 + H2O

Note that all catalysts are regenerated and only the alkene and oxygen are consumed. Without [copper(II) chloride](http://en.wikipedia.org/wiki/Copper%28II%29_chloride) as an [oxidizing agent](http://en.wikipedia.org/wiki/Oxidizing_agent) Pd(0) metal (resulting from [reductive elimination](http://en.wikipedia.org/wiki/Reductive_elimination) of Pd(II) in the final step) would precipitate out and the reaction would come to a halt (the stoichiometric reaction without catalyst regeneration was discovered in 1894). Air, pure oxygen, or a number of other oxidizers can then oxidise the resultant [CuCl](http://en.wikipedia.org/wiki/Copper%28I%29_chloride) back to CuCl2, allowing the cycle to repeat.

The initial stoichiometric reaction was first reported by Phillips[[4]](http://en.wikipedia.org/wiki/Wacker_process#cite_note-3)[[5]](http://en.wikipedia.org/wiki/Wacker_process#cite_note-4) and the Wacker reaction was first reported by Smidt et al.