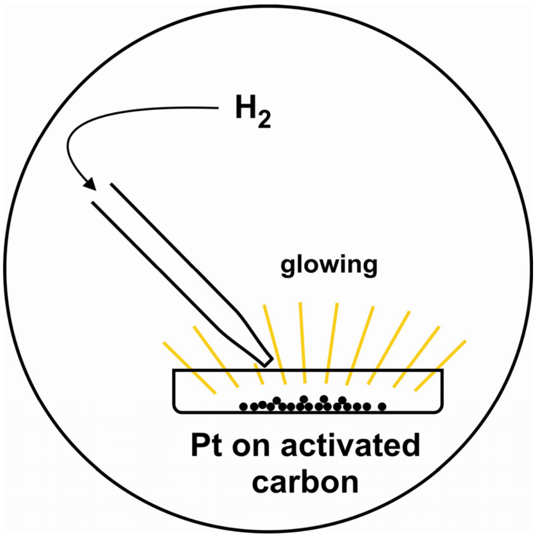
Catalytized Gas Ignition



Equipment:

pressure-reducing valve
glass tube with tapered end
flexible tube
tweezers
Petri dish
(optional: 50-mL beaker
glass rod)

Chemicals:

hydrogen (gas cylinder)
platinized quartz wool or
platinized activated charcoal
(optional: quartz wool
sodium hexachloroplatinate(IV) hexahydrate
ascorbic acid solution (5 wt.-%)
deionized water)

Safety:

hydrogen (H_2):

H220, H280
P210, P377, P381, P410 + P403

sodium hexachloroplatinate(IV) hexahydrate ($Na_2PtCl_6 \cdot 6\ H_2O$):

H301, H317, H318, H334
P261, P280, P301 + P310, P305 + P351 + P338, P342 + P311

Hydrogen is extremely flammable and forms explosive mixtures with air (explosive limits in air: 4 – 75 % per volume).
It is necessary to wear safety goggles and recommended to wear suitable work gloves. Because of the escaping hydrogen an adequate ventilation has to be provided.

Procedure:

Preparation of platinized quartz wool: 10 mg of sodium hexachloroplatinate(IV) hexahydrate are dissolved in 20 mL of deionized water. The quartz wool is washed with acetone for removal of disturbing residues on the surface and then well dried. The hexachloroplatinate solution and 10 mL of ascorbic acid solution are poured into the beaker and the mixture is stirred up well. Subsequently, a “flake” of cleaned quartz wool (approx. 0.5 – 0.6 g) is added to the solution. After a few hours the solution gets dark because platinum precipitates. The mixture should be allowed to stand *at least overnight* in the covered beaker. Thereby, the quartz wool should always be covered by liquid. Subsequently, the quartz wool that looks now gray is taken out of the solution, washed with deionized water and dried. Before use, the platinized quartz wool has to be heated thoroughly for a few seconds to activate it.

Procedure: Hydrogen out of a gas cylinder is directed through a glass tube onto platinized quartz wool held by tweezers or on a small heap of platinized activated charcoal in a Petri dish (a little bit of glass wool should be filled in the tapered end of the tube for avoiding backlash).

Observation:

After a little while, the catalyst begins to glow, and the gas jet ignites itself spontaneously with a gentle bang. The gas burns with a hot but nearly colorless flame.

Explanation:

Hydrogen "burns" to water according to

	$2\ H_2|g + O_2|g \rightarrow 2\ H_2O|l$		
$\Sigma\mu^\ominus$:	0 **>** –474.4	kG

$\Rightarrow$ chemical drive $\mathcal{A}^\ominus$: **+**474.4 kG

Necessary chemical potentials (T = 298 K, p = 100 kPa):

Substance	Chemical potential $\mu^\ominus$ [kG]
$H_2|g$	0
$O_2|g$	0
$H_2O|l$	–237.2

The chemical drive of the reaction is positive, i.e. the reaction should take place spontaneously. The reaction rate at room temperature is, however, immeasurably small because the "potential barrier" on the path from the reactants to the products is too high. But this "barrier" can be overcome by the flame of a lighted taper or match ("oxyhydrogen reaction"). By contrast, finely dispersed platinum as catalyst provides an alternative reaction path with a lower "barrier." The hydrogen gas ignites without initiating flame, the catalyzed reaction can be used quite the contrary as source for fire lighting. Based on this effect, Johann Wolfgang DÖBEREINER constructed in 1823 a pneumatic gas lighter, the famous "DÖBEREINER´s lighter."
Platinum as catalyst provides a surface on which the reaction can take place. It seems that both H_2 and O_2 undergo "dissociative chemisorption" on the platinum surface. By stepwise reaction of the chemisorbed atoms (firstly, a H atom diffuses to an adsorbed O atom, forming a surface-coordinated hydroxyl group, and subsequently, this species reacts with a second H atom) water is formed. Because the surface atoms of the catalyst are responsible for the acceleration of the reaction a surface as large as possible and therefore a high degree of dispersion of the platinum is desirable. The very small particles of the active phase are deposited on a support material for stabilization, in our experiment on quartz wool or activated charcoal.

Disposal:

The catalyst can be reused many times. Otherwise, the platinum has to be treated as heavy metal waste.