

Hydrogen causes metal to break

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Hydrogen is considered the fuel of the future. Yet this lightest of the chemical elements can embrittle the metals used in vehicle engineering. The result: components suddenly malfunction and break. A new special laboratory is aiding researchers' search for hydrogen-compatible metals..

Most likely, there is hardly a soul that cannot recall K.I.T.T. - the legendary talking supercar from the US television series "Knight Rider". A [hydrogen](#) turbo motor fuels the fantasy vehicle and propels it on the chase for the bad guys at over 300 miles an hour. In the future, cars may be equipped with hydrogen propulsion not just in the movies, but in real life as well. In the transportation and energy sectors, hydrogen is viewed as an eventual alternative to the raw materials of fossil-fuel power, such as coal, petroleum and natural gas. However, for metals like steel, aluminum and magnesium - which are commonly used in automotive and [energy technology](#) - hydrogen is not quite ideal. It can make these metals brittle; the ductility of the metal becomes reduced. Its durability deteriorates. This can lead to sudden failure of parts and components. Beside the [fuel tank](#) itself, or parts of the fuel cell, but ordinary components like ball bearings could also be affected. These are found not only in the car, but also in almost all industrial machinery.

This lightest of the chemical elements permeates the raw materials of which the vehicle is made not only when filling the tank, but also through various manufacturing processes. Hydrogen can infiltrate the metal lattice through corrosion, or during chromium-plating of car parts. Infiltration may likewise occur during welding, milling or pressing. The result is always the same: the material may tear or break without

warning. Costly repairs are the consequence. To prevent cracks and breakage in the future, the researchers at the Fraunhofer Institute for Mechanics of Materials IWM in Freiburg are studying hydrogen-induced embrittlement. Their objective: to find materials and manufacturing processes that are compatible with hydrogen. "With our new special laboratory, we are investigating how and at which speed hydrogen migrates through a metal. We are able to detect the points at which the element accumulates in the material, and where it doesn't," says Nicholas Winzer, researcher at IWM.

Since the risk potential mostly emanates from the diffusible, and therefore mobile, portion of the hydrogen, it is necessary to separate this from the entire hydrogen content. Researchers can release and simultaneously measure the movable part of the hydrogen by heat treatment, where samples are continuously heated up. In addition, the experts can measure the rate that hydrogen is transported through the metal while simultaneously applying stress to the material samples mechanically. They can determine how the hydrogen in the metal behaves when tension is increased. For this purpose, the scientists use special tensile test equipment that permit simultaneous mechanical loading and infiltration with hydrogen. Next, they determine how resistant the material is. "In industry, components have to withstand the combined forces of temperature, mechanical stress and hydrogen. With the new special laboratory, we can provide the necessary analytical procedures," as Winzer explains the special feature of the simultaneous tests.

The researchers use the results from the laboratory tests for computer simulation, with which they calculate the hydrogen embrittlement in the metals. In doing so, they enlist atomic and FEM simulation to investigate the interaction between hydrogen and metal both on an atomic and a macroscopic scale. "Through the combination of special laboratory and simulation tools, we have found out which materials are suitable for

hydrogen, and how manufacturing processes can be improved. With this knowledge, we can support companies from the industry," says Dr. Wulf Pfeiffer, head of the process and materials analysis business unit at IWM.

Provided by Fraunhofer-Gesellschaft

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