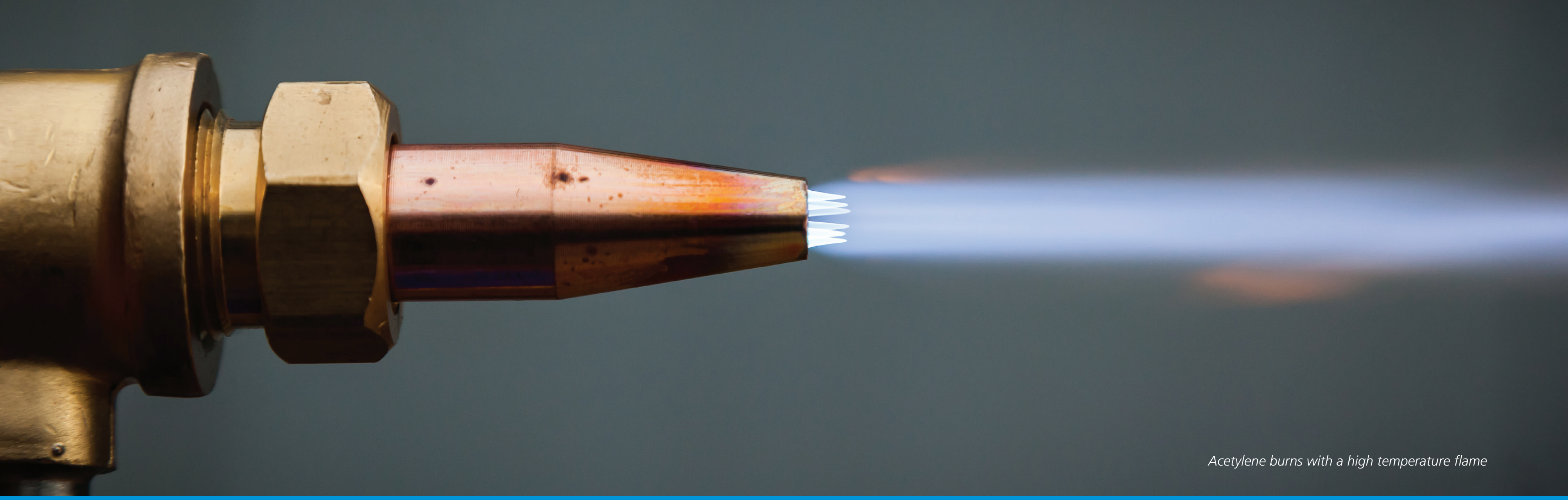

Acetylene burns with a high temperature flame

MICROWAVE PLASMA FOR NATURAL GAS TRANSFORMATION TO ACETYLENE AND HYDROGEN

Methane splitting is now being used to generate 'turquoise' hydrogen from natural gas by companies, such as Monolith Materials and Plenesys. Their processes rely on DC and AC plasma respectively to convert natural gas into turquoise hydrogen and solid carbon. Monolith Materials in Nevada, USA has the highest level of technology maturity of the various turquoise hydrogen start-ups. Their process builds on the technology developed more than 2 decades ago by Kværner. Another US-based start-up, Transform Materials, uses a different technology based on microwave plasma to split the methane molecule into hydrogen and acetylene.

Microwave plasma for natural gas transformation to acetylene and hydrogen

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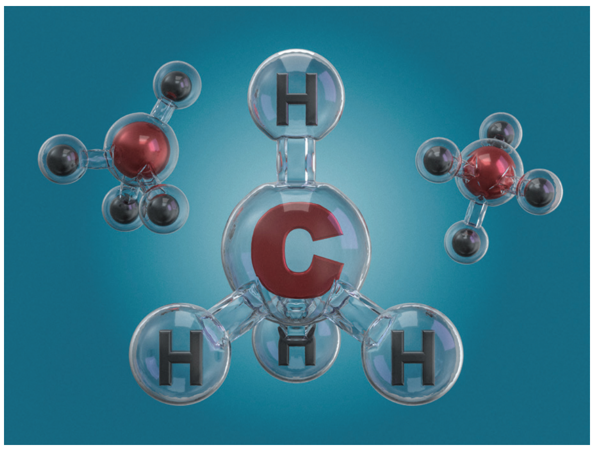

Methane from natural gas can be split to hydrogen and acetylene

Microwave plasma methane splitting

Methane splitting to produce acetylene and hydrogen was described by Louis S. Kassel in his 'Thermal decomposition of methane' paper of 1932. The reaction pathway is methane to ethane (some hydrogen is released) to ethylene (more hydrogen is released) to acetylene (yet more hydrogen is released) to carbon (the final hydrogen atoms are split from the carbon atom). The production of acetylene and hydrogen can be achieved through the Kassel reaction if it is interrupted before the final stage of acetylene decomposition to form solid carbon. The avoidance of solid carbon production may be an advantage to simplify downstream material handling.

Following the microwave plasma reactor, the Transform Materials process uses Temperature Swing Adsorption (TSA) to remove heavier hydrocarbon impurities from the product gas stream. Then, the lighter hydrogen and acetylene leaving the TSA are separated to capture the acetylene. Finally, the hydrogen is purified using a Pressure Swing Adsorption (PSA) system, which is a common final-stage hydrogen purification technology.

Acetylene is a versatile chemical building block. It can be used in the specialty chemicals sector to synthesise vitamins A and E. It is also used to produce fragrances and solvents. In bulk chemicals, acetylene is used to make acetic acid and 1, 4, Butanediol, which is fundamental to the production of artificial rubber.

Perhaps the best-known application for acetylene is in metal cutting and welding. It is a highly reactive gas and when burned with oxygen it yields a very high temperature flame at around 2200°C, which is sufficiently hot to cut steel. Oxy acetylene torch sets are common in maintenance workshops in the hydrocarbon processing sector. Torches of this kind are also used in ship breaking on the beaches of Bangladesh and are ubiquitous for building demolition projects to cut the reinforcing steel bars that are fixed inside concrete structures.

Electrification of industrial processes to support decarbonisation

Microwave plasma energy was also used by Atlantic Hydrogen in their turquoise hydrogen pilot plant in Eastern Canada. Today, also in Canada, the New-Brunswick based start-up Nu:ionic is developing microwave based catalytic reforming to produce hydrogen in a process with integrated carbon capture.

Acetylene is used to produce synthetic rubber

The use of microwave energy to produce hydrogen from natural gas is an alternative to the use of fossil fuel combustion, which is required in the traditional steam methane reforming process. The avoidance of combustion means that carbon dioxide emissions can be eliminated from that part of the process if renewable electricity is used to for the microwave energy or plasma generation. The electrification of industrial processes will be essential in the quest to decarbonise hydrocarbon processing and the energy sector as we look ahead to 2050 and climate neutrality.

The methane splitting process can be further decarbonised using biomethane to substitute natural gas. However, in all cases, fugitive methane emissions must be avoided to prevent the release of this potent greenhouse gas to the atmosphere. There is a huge role here for methane gas detection systems and remote monitoring equipment to sound the warning bell on methane leaks and trigger maintenance to minimise the impact of methane emissions on climate change.

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