# Investigation of methane pyrolysis with metal beads for scalable turquoise hydrogen production

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## Abstract

Hydrogen is a clean energy carrier that plays a crucial role in reducing greenhouse gas (GHG) emissions, with its environmental impact largely dependent on the production method. Turquoise hydrogen, produced via methane pyrolysis, offers a sustainable approach by generating hydrogen without carbon dioxide emissions. The core reaction involves breaking carbon-hydrogen bonds, a highly endothermic process, where catalysts are essential in lowering the activation energy. This study investigates the catalytic performance of SUJ2 steel beads for methane pyrolysis in a 1-meter tube reactor under atmospheric pressure. Methane conversion was analysed as a function of temperature, flow rate, and catalyst deactivation. Using 5 mm beads, methane conversion reached 99% at 1000 °C with a flow rate of 0.1 LPM but dropped to 20% at 1 LPM. In contrast, a homogeneous mixture of 5 mm and 3 mm beads achieved 100% conversion at 1000 °C with a flow rate of 0.1 LPM, though conversion declined to 24% at 1 LPM. The use of mixed bead sizes reduced bed porosity, ultimately enhancing methane conversion efficiency. Compared to conventional catalysts, SUJ2 steel beads demonstrated superior long-term stability, recyclability, and scalability. These findings highlight SUJ2 steel beads as a cost-effective and durable alternative for large-scale methane pyrolysis. To significantly reduce global carbon emissions, methane pyrolysis must be adopted on an industrial scale, with solid carbon storage ensuring long-term sustainability.