Electric catalysis: from renewable energy to valorized gas

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Gas transformations are often (highly) endothermic and, hence, require a suitable reactor design to transfer the necessary heat towards the reacting gas. Methane reforming, either for syngas ($CO + H_2$) or hydrogen (H_2) production is the most widespread example of such a reaction and is typically performed in relatively narrow reactor tubes that are suspended in a (gas fired) furnace. Despite this specific design, the reaction largely remains being performed in a heat transfer limited regime.

Within the realm of the transition towards sustainable and circular processing, the use of electricity as an energy source, provides a unique opportunity for innovating the reactor configuration for (highly) endothermic reactions. Various interesting options are available for bringing the necessary heat inside the reactor, no longer suffering from the transfer limitations induced by convection faced in conventional reactor furnaces. Joule heating (based on resistance), microwave heating, induction heating have emerged as the most promising techniques. Among these, Joule heating stands out because of its efficiency for electricity conversion into heat. The related challenge is to properly contain the electrical current where the heat needs to be generated.

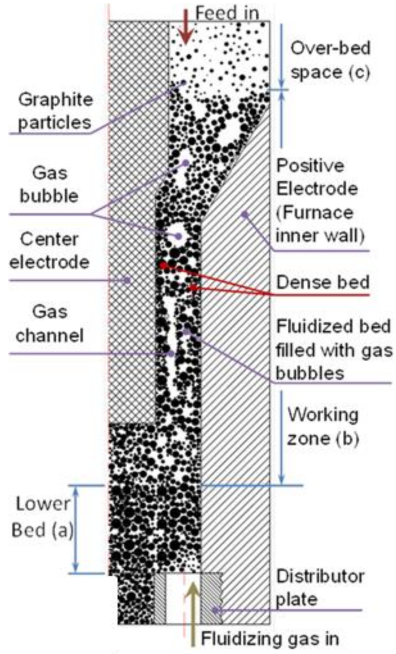

Figure 1: Segmental cross section of a fluidized bed reactor [1]

The ElectroThermal Fluidized Bed (ETFB) reactor is a recently developed reactor technology to meet these specific requirements, see Figure 1 [1]. The central part of the reactor comprises a working zone (b) which is contained between 2 electrodes, i.e., a centrally located one and a second one on the internal wall of the reactor, and spans the major part of the reactor height. A fluidized catalyst bed consisting of dense zones and gas bubbles fills the space between the electrodes and is made up of the appropriate composition to ensure the meticulous balance between conductivity and resistivity for heat generation.

Intended gas conversion applications for an ETFB reactor involve methane pyrolysis for hydrogen production with solid carbon formation as byproduct [2]. It concerns a widely investigated reaction, relevant not only for stranded gas valorization, but also for the upgradation of locally produced biogas. Another, even more innovative, reaction entails COS decomposition into CO and elemental sulphur [3] as the second step in the treatment of mixed CO_2 and H_2S. This e-CODUCT technology represents a major step forward in the efficient reduction and valorization of refinery off-gases [4].

References:

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Joris W. Thybaut (°1975, Ghent Belgium) is senior full professor in catalytic reaction engineering at the Laboratory for Chemical Technology at Ghent University since September 2022. He obtained his PhD on Single-Event MicroKinetic (SEMK) modeling of hydrocracking and hydrogenation at Ghent University in 2002 after which he went to the 'Institut des Recherches sur la Catalyse' in Lyon, France, for a postdoc on high throughput experimentation. Prof. Thybaut was first appointed at Ghent University in 2005 and, since then, actively investigates a variety of large-scale industrial hydrocarbon conversion reactions and more particularly, the rational design of the corresponding catalysts and reactors. Research projects range from bilateral contracts with industrial partners up to government funded large scale integrated projects, either as partner (PSYCHE, P2PC,…), PI (C123, SPICY,…) or coordinator (e-CODUCT, GREEN-B2B…). Prof. Thybaut served as visiting professor at the Japanese Advanced Institute for Science and Technology in the period 2020-2021. He’s also one of the leading academics in the Eurokin consortium on kinetics and reactors (www.eurokin.org). His work has received appreciation as editor’s choice in AIChE J. and has been on the cover of various journals, among others the inaugural issue of ACS Engineering Au. A steady evolution from more classical refining reactions to renewables valorization can be discerned in his research activities. Most recently, as part of bilateral collaborations the scope of the investigated chemistry is further being extended towards inorganic reactions, pharmaceutical applications and circular chemistry.