LABORATORY FOR CHEMICAL TECHNOLOGY
Technologiepark 125, 9052 Gent, Belgium

Coach	**Supervisor(s)**	**Funding**
Parviz Yazdani	Prof. Mark Saeys, De Vos Yoran	

Unravelling attrition mechanism of the supported lanthanum oxide based OCM catalysts in fluidized bed reactors

Aim

Understanding the attrition mechanism of the OCM catalysts in fluidized bed reactors to improve their stability.

Justification

Within the H2020 ADREM project, the gas-solid vortex reactor (GSVR) and supported lanthanum based catalysts were designed for Oxidative coupling of methane (OCM). First OCM experiments in GSVR showed that the time for stable operation was limited due to the catalyst deterioration. Catalyst particles undergo very rapid attrition and as a consequence become very small under high shear forces in GSVR. The Stoke's number of the particles hence begins to decrease and the particles are removed by the gas streamlines.

There are three factors that affect the attrition process in a fluidized bed reactor, including (i) particle properties (ii) fluidization conditions, and (iii) fluidized bed structure parameters. In this master thesis, we will study the particle properties with a focus on mechanical strength.

One of the methods to assess the mechanical strength of catalysts is their attrition index. A low attrition index is necessary for solid materials to form a rotating, sustained solid bed in the vortex reactors. Attrition in catalyst beds can be categorized into two types; particle fragmentation and surface abrasion. In the former mechanism, a particle is broken into multiple smaller fragments which results in smaller particles. Alternatively, abrasion occurs when a lot of fines are removed from the surface of a particle, while the size distribution of mother particles is only slightly changed. It should be noted that attrition is a time-dependent process and may change systematically with time. Hence, studying the attrition mechanism of the synthesized materials as a function of attrition time will be crucial in the design of highly stable OCM catalyst.

The aim of this master thesis will be improving the stability of the developed catalyst at LCT via coating of the supported La_2O_3 based catalysts. The synthesized material will be characterized using XRD, XPS, BET, microscopy and Dynamic Image Analysis. To evaluate the mechanical integrity of the synthesized materials, the time-dependent attrition resistance will be investigated in a three-hole attrition unit at the CAST team in VITO, and will be compared with a benchmark of the same size range. The catalytic performance of the developed catalysts will be investigated in the fixed bed reactor at LCT.

Program

1. Literature study: (i) catalysts designed for OCM, (ii) deactivation mechanism of catalysts in fluidized bed reactors with a focus on particle attrition
2. Synthesis of new OCM catalysts at LCT
3. Kinetic study of the new catalysts in fixed bed reactor at LCT
4. Characterization of the designed materials at the CAST team in VITO
5. Unravelling attrition mechanism of the LCT-OCM catalyst and newly synthesized materials

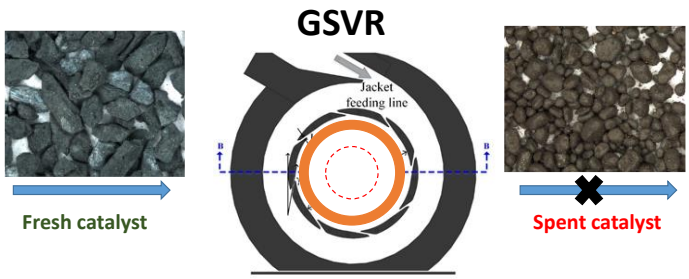

Figure 1: Schematic of a gas-solid vortex reactor.

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