FAST CARD Newsletter

FASTCARD - FAST industrialisation by CAtalysts Research and Development

No. 2 – October 2014

FASTCARD

Project Meeting 28-29 July in Ghent, Belgium

The EU FP7-funded project FASTCARD had its second meeting with 35 participants from 8 different countries in Ghent on 28-29 July 2014 (Fig. 1). In this meeting, first results were reported, on the first day in different working group sessions and on the second day in plenary sessions.

According to the FASTCARD innovative methodology (Fig. 2), in the first six months of the project long pilot runs with state of the art catalysts using real feeds have been conducted for hydrocarbon reforming, CO2 Fischer Tropsch synthesis, hydrotreating and co-fluid catalytic cracking (co-FCC).

Figure 1: Group photo taken in front of a Ghent University building and photo from working group sessions.

Model development has started with the aim to develop powerful microkinetic models as well as fundamental quantitative structure activity relationships to aid the rational design of nano-catalysts. Also characterization of the used state of the art catalysts has started.

FASTCARD is devoted to two major value chains for the catalytic conversion of biomass to biofuels. The gasification route with WPs 1 and 2 consists of gasification followed by hydrocarbon reforming and Fischer Tropsch synthesis.
The liquid route with WPs 3 and 4 comprises pyrolysis followed by hydrotreating and co-FCC.
In the following, the main work packages are described in greater detail.

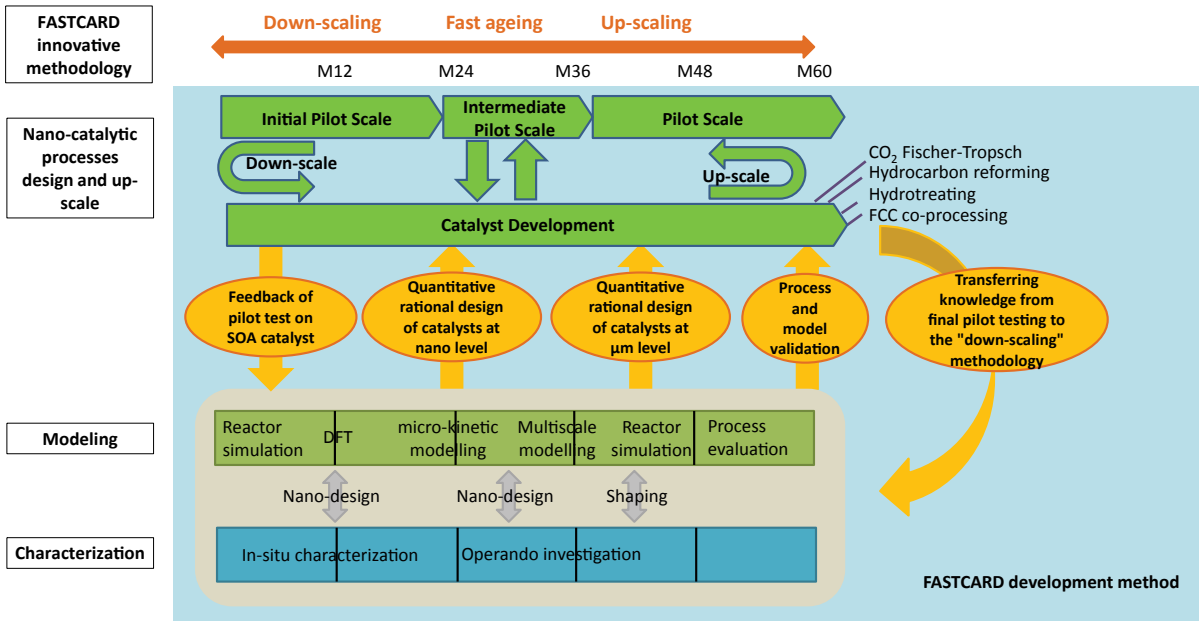

Figure 2: FASTCARD development method.

WP1 is devoted to hydrocarbon reforming. The gasification route starts with fluidized bed gasification at low temperatures around 850 °C, which is highly efficient and flexible with regard to the biomass feedstock. Since the synthesis gas thus produced contains about 15 vol.-% hydrocarbons which contain more than 60 % of the energy, gasification has to be followed by hydrocarbon reforming. The route chosen is the catalytic hydrocarbon reforming, which should be improved so that the fluctuating poison level can be handled. A two-step procedure is developed with robust and cheap catalysts in the first step and improved tailored catalysts in the second step.

WP2 deals with Fischer Tropsch synthesis. Iron catalysts are chosen since they offer advantages for BTL (biomass to liquids) applications: Firstly, they can operate at higher temperatures, where higher reaction rates and conversions are possible. Secondly, due to their high water gas shift activity, CO2-containing synthesis gas can be used. Within the project, next-generation supported iron catalysts are to be developed specifically for BTL applications. For this reason, the deactivation mechanism has to be understood in detail so that catalyst durability can be improved.

In addition, the catalyst stability at higher temperatures as well as the selectivity to C5+ products have to be increased.

The topic of **WP3** is hydrotreating of pyrolysis oils. The first step is the stabilization of the oils on a commercial Picula™ catalyst followed by full deoxygenation on a conventional HDO catalyst. The aim of the project is to optimize the Picula™ catalyst for a stability > 500 h on stream and a hydrogen consumption < 250 NL/kg. In addition, the HDO catalyst should be optimized so that only partial deoxygenation is necessary in order to reach carbon yields > 0.8 g per g of pyrolysis oil.

WP4 is devoted to co-FCC. Since co-feeding of biooil causes significant yield shifts to undesired by-products and damaging of catalysts with “new” contaminants from biomass, the existing catalysts have to be improved to enable higher percentages of biomass co-feeding. The current faujasite catalysts will be modified, and new zeolites structures will be tested. Quantitative structure activity relationships will be established including model compound tests for a rational catalyst design.

In order to get to know the partners of FASTCARD (table below), 3 of the partners are introduced on the following pages.

The rest of the partners will be described in later newsletters.

Partner	Country	Logo
Stiftelsen SINTEF	Norway	
Centre National de la Recherche Scientifique	France	
ENI S P A	Italy	
Johnson Matthey Plc	United Kingdom	
Boreskov Institute of Catalysis, Siberian Branch of Russian Academy of Sciences	Russia	
Grace Gmbh & Co Kg	German	
Universitaet Stuttgart	Germany	
Stichting Energieonderzoek Centrum Nederland	Netherlands	
Universiteit Gent	Belgium	
B T G Biomass Technology Group Bv	Netherlands	
Process Design Center Bv	Netherlands	
Norwegian University of Science and Technology (NTNU)	Norway	
Saint-Gobain Centre de Recherches et D'etudes Europeen	France	
REPSOL SA	Spain	

Johnson Matthey (JM)

Brief description of the organisation and of the department contributing to the execution of the project

Johnson Matthey (www.matthey.com) is a UK based speciality chemicals company focused on its core skills in catalysis, precious metals, fine chemicals and process technology. The company employs around 11000 people worldwide located in over 30 countries; around 10% of those work in an R&D function. Johnson Matthey's principal activities are the manufacture of autocatalysts, heavy duty diesel catalysts and pollution control systems, catalysts and components for fuel cells, catalysts and technologies for chemical processes, fine chemicals, chemical catalysts and active pharmaceutical ingredients and the marketing, refining, and fabrication of precious metals. More than half of JM's products have a direct environmental benefit, a figure that is set to increase as a key part of the company's growth strategy is to focus on emerging environmental opportunities. Johnson Matthey's participation in FASTCARD will be through the Technology Centre (JMTC) based at Sonning Common in the UK. This central facility acts as a focal point for the development of new technologies into emerging market applications.

Role in project and previous experience relevant to the task

JM's role in FASTCARD will be principally in WP1 (reforming) and WP2 (Fischer Tropsch), in the development, testing, scale-up and process implementation of nanocatalysts.
Syngas catalysis is a core competence of JM, and the company has a market leading position in both syngas catalysis and process technology. The research groups at JMTC are integrated into the commercial development activities, which will ensure a fast exploitation of successful results originating from FASTCARD.

Person assigned to the project

Sue Ellis is Low Carbon Technology Manager. She has been working at JM since 1994. She is a Catalyst scientist with 18 years' experience in syngas and low carbon technologies. She has participated in the following EU projects: CAPRI, PROFUEL, BIOFEAT, INNOCUOUS, GREENSYNGAS, NESSHy, FCGEN, NEMESIS2+.
Debra Jones is a Senior Scientist. She has worked for JM since 2004 and has experience in catalyst manufacture, characterization and testing in a number of project areas. Debra worked on EU FP6 HYDROSOL II in renewable hydrogen generation. Commercial development projects include NH3 SCR, syngas and natural gas purification, and Fischer Tropsch catalysis. Debra will be the leader of WP2 (CO2 FTS) on behalf of JM.
Stephen Poulston is a Senior Principal Scientist. He has been working at JM since 1998. He is a catalyst scientist with ~20 years' experience in syngas technologies. He has previously participated in the OCMOL and SusFuelCat (FP7-310490) EU projects and has an active interest in catalysts and process technology for thermochemical biomass conversion. Stephen will be WP1 co-leader.

Previous participation in other projects related to this project

Most closely aligned is GREENSYNGAS. Other relevant include BIOELECTRICITY, NEMESIS2+, GREENSYNGAS

Special Equipment available for the project

The JM Technology Centre has established facilities for the preparation, advanced characterisation and testing of materials, as well as access to pilot scale manufacturing assets and state-of-the art analytical and electron optic equipment. Particularly relevant for this project will be dedicated tar reforming and FT testing rigs.

References (publications) and patents related to the project

1. JM pending FT patents include WO2010/049714A1, US2010/0048742A1, O2010/049715A1 G.J.Kelly in 'Advances in FT Synthesis, Catalysts and Catalysis', B.H.Davis (eds), CRC Press 2010
2. Steele, A., Smith, A. and Poulston, S., 2011, Catalytic Tar Destruction From Model Biomass Gasification Streams. Proceedings of the bioten conference on biomass, bioenergy and biofuels 2010. Edited by Bridgwater, A.V., CPL Press, 752-758.

GRACE GmbH & Co KG

Brief description of the organisation and of the department contributing to the execution of the project

Grace is a leading global supplier of catalysts, engineered and packaging materials, specialty construction chemicals and building materials. The company's three industry-leading business segments—Grace Catalysts Technologies, Grace Materials Technologies and Grace Construction Products—provide innovative products, technologies and services that improve the products and processes of our customer partners around the world.

Grace Catalysts Technologies produces and sells catalysts and related products used in refining, petrochemical and other chemical manufacturing applications. The Grace Catalysts Technologies business segment includes three main product lines: Refining Technologies, Advanced Refining Technologies and Specialty Catalysts. Our Refining Technologies product line includes:

- Fluid catalytic cracking, or FCC, catalysts, that help to "crack" the hydrocarbon chain in distilled crude oil to produce transportation fuels, such as gasoline and diesel fuels, and other petroleum based products;
- FCC additives used to reduce sulfur in gasoline, maximize propylene production from refinery FCC units, and reduce emissions of sulfur oxides, nitrogen oxides and carbon monoxide from refinery FCC units.

Role in project and previous experience relevant to the task

GRACE is the leader of the work package 4 – Co-FCC – aligning the activities of the work package partners within the FASTCARD project. Moreover, GRACE will develop bench and pilot plant scale catalyst systems, based on the rationally designed zeotype materials provided by the respective work package partners. Furthermore, GRACE leads the work packages 7 (Demonstration of scaled up catalyst), and contributes to WP 8 as Exploitation Manager. Previous expertise in the field of biomass conversion could be gathered within the BioBoost EU project (focused on catalytic pyrolysis) as well as during BioCat.

Person assigned to the project

Dr. Stephan Wellach studied chemistry at the University of Stuttgart where he also obtained his PhD under the supervision of Prof. Jens Weitkamp. From 1998 – 2006, he worked for Süd-Chemie (now Clariant) taking increasingly responsible roles in product development, before becoming the Manager of the Manufacturing Plants in Heufeld and Mossburg. Since 2007, he is working as Manager in the R&D Department of Grace Catalysts Technologies in Worms.

Dr. Silke Löning studied Chemical Engineering at the Technical University of Clausthal, where she received her PhD under the supervision of Prof. Ulrich Hoffmann. Since 2000 she is working in the R&D Department (Pilot Plant) of Grace Catalysts Technologies Worms. After her maternity leave she is now responsible for Patent and literature searches within the product line worldwide.

Dr. Edgar Jordan received his Diploma in Chemistry as well as his PhD under the supervision of PD Dr. Hubert Koller in the Department of Physical Chemistry at the University of Münster. From 2006-2008, he conducted postdoctoral research in the Department of Chemical Engineering at the Texas A&M University in College Station, TX, USA in the group of Prof. Daniel F. Shantz.

Since 2008, he is working in the R&D Department of Grace Catalysts Technologies in Worms, Germany. His research interests are in the field of zeolite synthesis, characterization of solids (especially using spectroscopic methods), as well as heterogeneous catalysis.

Previous participation in other projects related to this project

GRACE is a partner in the EU projects BioBoost and BioCat.

Special Equipment available for the project

A wide array of catalyst characterization, deactivation and bench scale testing methods is available for the project. Furthermore, the preparation of catalysts for internal use as well as for distribution to the project partners is planned on the bench (100 g – 1 kg) as well as on the pilot plant scale (up to 100 kg).

B.T.G. Biomass Technology Group BV

Brief description of the organisation and of the department contributing to the execution of the project

BTG Biomass Technology Group BV is a private company (SME) of consultants, researchers and engineers specialised in the sustainable energy production from biomass and waste. The company has a staff of approx. 35 people. Started in 1979 as specialists on R&D, implementation, monitoring and evaluation of gasifiers systems, BTG's expertise covers a broad variety of thermal energy conversion technologies (pyrolysis, hydrotreating, gasification, supercritical gasification, torrefaction, combustion, liquefaction, carbonisation), and has extensive experience and a strong involvement in European bio-energy R&D programs, in particular related to biomass pyrolysis, oil hydrogenation and gasification RD&D. The BTG lab is well suited to undertake all necessary activities pertaining to thermal conversion of biomass. Among its facilities are:

- 0.5 kg/h and a 5 kg/h lab scale units, a 250 kg/h pilot scale pyrolysis equipment (for flash pyrolysis)
- Two bio-oil hydrotreating units (fixed beds, 100 ml and 2 L volume, respectively
- Two supercritical gasification units (tubular bed reactors, volume from 200 ml to 3 L)
- PDU scale bio-oil combustion and gasification equipment (flame tunnel, diesel engine) and
- Laboratory analysis equipment for biomass and pyrolysis oil characterisation.

Role in project and previous experience relevant to the task

BTG's main role in FASTCARD is in the treatment of pyrolysis liquids to produce intermediate products with the proper specifications for co-feeding in FCC units.

Person assigned to the project

Dr. ir. Robbie Venderbosch is senior process engineer in thermal conversion technologies with expertise and responsibilities in a.o. fluidised bed system coupled with chemical reaction, biomass energy processes (from concept to detailed design), operation of laboratory, pilot and demonstration scale set-ups and process instrumentation and process control (both software and hardware). He is in charge of BTG's research on the use of pyrolysis oils and responsible for the work to be carried out in SUSFUELCAT, focussed on the Aqueous Phase Processing of carbohydrate feed stocks, and in FASTCARD, to allow pyrolysis liquids to fed into oil refineries.
Dr. ir. Bert van de Beld is BTG's director of technology. He is technical coordinator of 2 FP7 projects, involving the PO demo project EMPYRO and the Russian-EU cooperation project on the use of bio-liquids in engines and turbines. He is a member of the programme committee of the Dutch research program on the development and use of Sustainable hydrogen (ACTS), and he was also representing the Netherlands in the IEA-hydrogen task 27.

Previous participation in other projects related to this project

Biocoup; Supermethanol; Empyro: SusFuelCat; Bioliquids-CHP; Supiabio; BioCore.

Special Equipment available for the project

Two bio-oil hydrotreating units (fixed beds, 100 ml and 2 L volume); supercritical gasification units

References (publications) and patents related to the project

1. Venderbosch, R. H.; Ardiyanti, A. R.; Wildschut, J.; Oasmaa, A.; Heeres, H. J., Stabilization of biomass-derived pyrolysis oils. Journal of Chemical Technology & Biotechnology 2010, 85 (5), 674-686;
2. Venderbosch, R. H.; Prins, W., Fast pyrolysis technology development. Biofuels, Bioproducts and Biorefining 2010, 4 (2), 178-208.
3. Wildschut, J.; Iqbal, M.; Mahfud, F. H.; Cabrera, I. M.; Venderbosch, R. H.; Heeres, H. J., Insights in the hydrotreatment of fast pyrolysis oil using a ruthenium on carbon catalyst. Energy & Environmental Science 2010, 3 (7), 962-970.
4. Wildschut, J.; Arentz, J.; Rasrendra, C. B.; Venderbosch, R. H.; Heeres, H. J., Catalytic hydrotreatment of fast pyrolysis oil: Model studies on reaction pathways for the carbohydrate fraction. Environmental Progress & Sustainable Energy 2009, 28 (3), 450-460.
5. Ardiyanti, A. R.; Khromova, S. A.; Venderbosch, R. H.; Yakovlev, V. A.; Heeres, H. J., Catalytic hydrotreatment of fast-pyrolysis oil using non-sulfided bimetallic Ni-Cu catalysts on a δ-Al2O3 support. Applied Catalysis B: Environmental 2012, 117–118 (0), 105-117.
6. Ardiyanti, A. R.; Venderbosch, R. H.; Heeres, H. J. In Process-Product Studies on Pyrolysis Oil Upgrading by Hydrotreatment with Ru/C Catalysts, 2009 AIChE Spring Annual Meeting, Tampa, Tampa, 2009.