Institut régional de recherche Charles Viollette

UCCS UNITÉ DE CATALYSE ET CHIMIE DU SOLIDE

CRIStAL Centre de Recherche en Informatique, Signal et Automatique de Lille

REALCAT

une plateforme de criblage catalytique haut débit dédiée au développement de catalyseurs pour les bioraffineries

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Context: development of new catalysts

- Catalysis is of upmost interest in crucial domains at the inner core of current societal demands
  - Energy, Environment, Food, Health,…

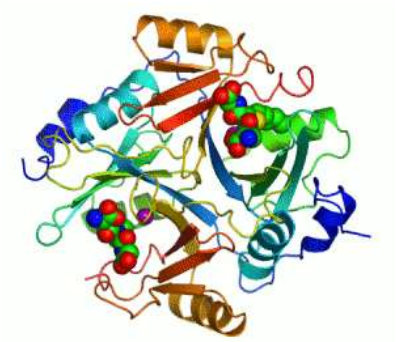
- Catalysts market is growing quickly (5%/y)
  - 20,6 Billions $ expected in 2018

Source: « World Catalyst », Freedonia, 2017

Not one but several types of catalysts

- **Chemocatalysts**
  - Solid
  - Dissolved in a liquid phase

- **Biocatalysts**
  - Enzymes,…



One of the REALCAT challenge= combine both types of catalysts to create HYBRID catalysts

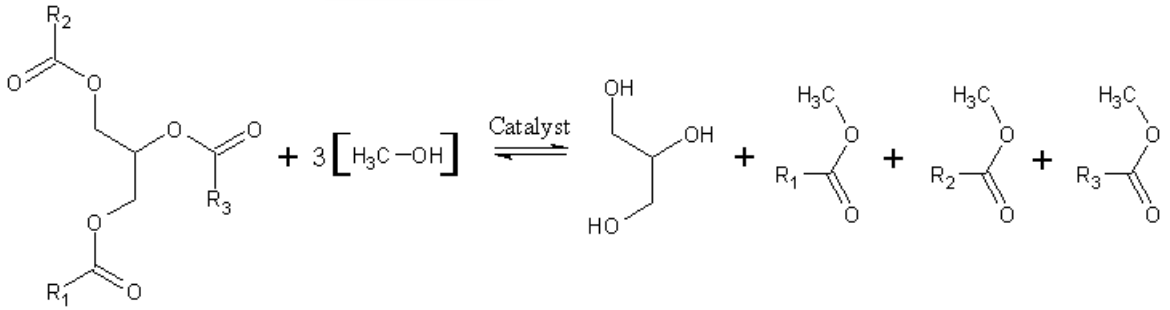
A NEW CATALYSIS “GOLD AGE”

- Transition from fossil to renewables and the development of biorefineries urges researchers **to rethink all the industrial catalysis**
- Necessity to adapt the catalysts to the specificity of renewable resources:
  - Water resistant
  - Oxygenated and functionalized reactants
  - …

How do we proceed to develop a new catalyst?

- **No predictive method** to design *a priori* a catalyst for a given reaction. **The trial and error experimental approach** is still **necessary**.

- For each reaction a specific catalyst must be developped.

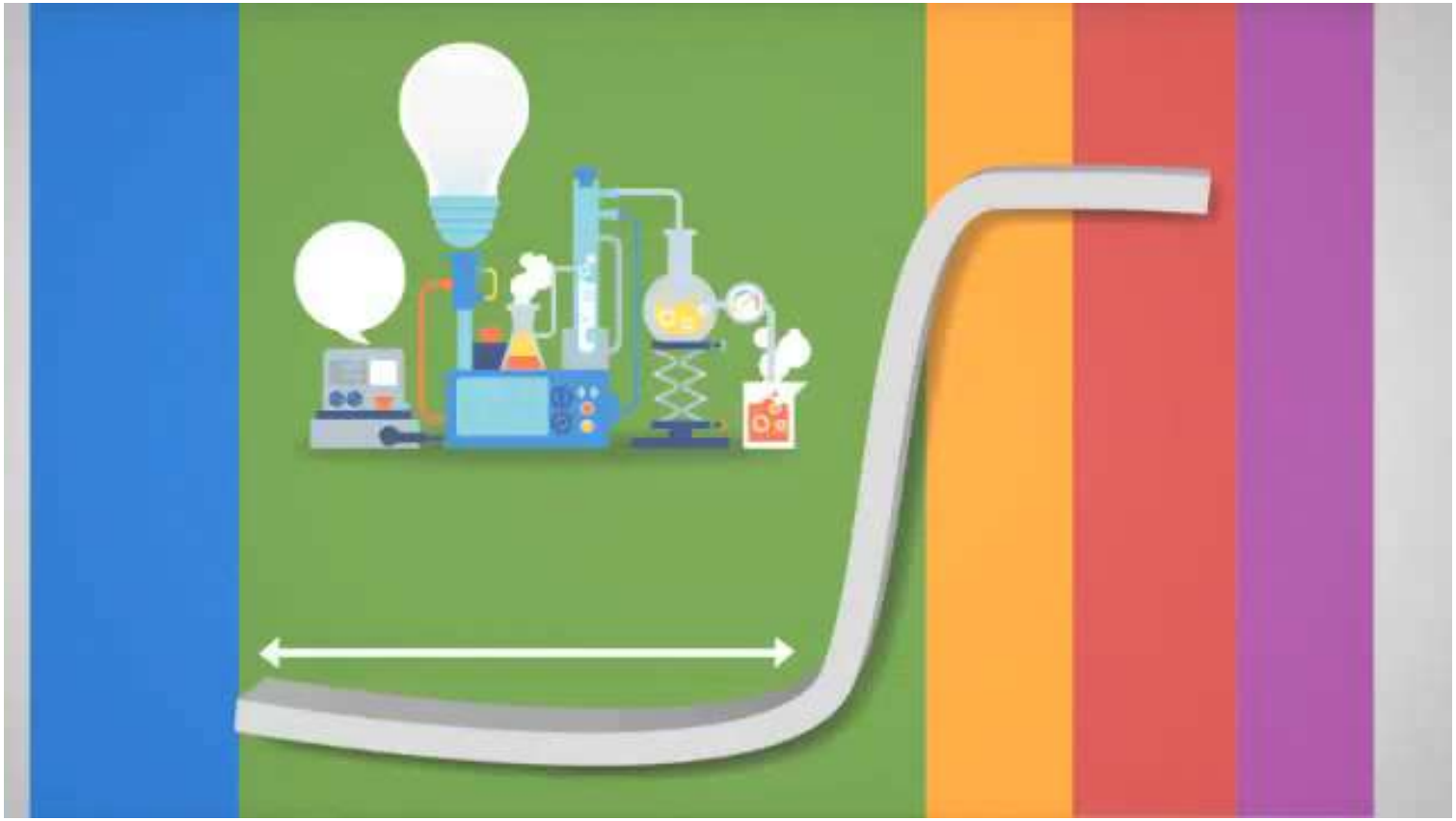


INNOVATION IN CATALYSIS

- **A - Forefront fundamental research**
  - Development of new catalytic concepts
  - "*A priori*" theoretical prediction not yet possible
- **B - Experimental phase**
  (synthesis, characterization and testing)
  - "Trial and error" method still needed

    → Time- and money-consuming
- **C – Interpretation**
  - Correlation between physico-chemical/biological properties and catalytic performances
- **D – Upscaling**: tests at the pilot scale
- **E - Commercialization**

Acceleration of the experimental phase



PERFORMANCE

TIME

What is REALCAT ?

- Advanced High-Throughput Technologies Platform dedicated to Biorefineries (but also other!) Catalysts Design

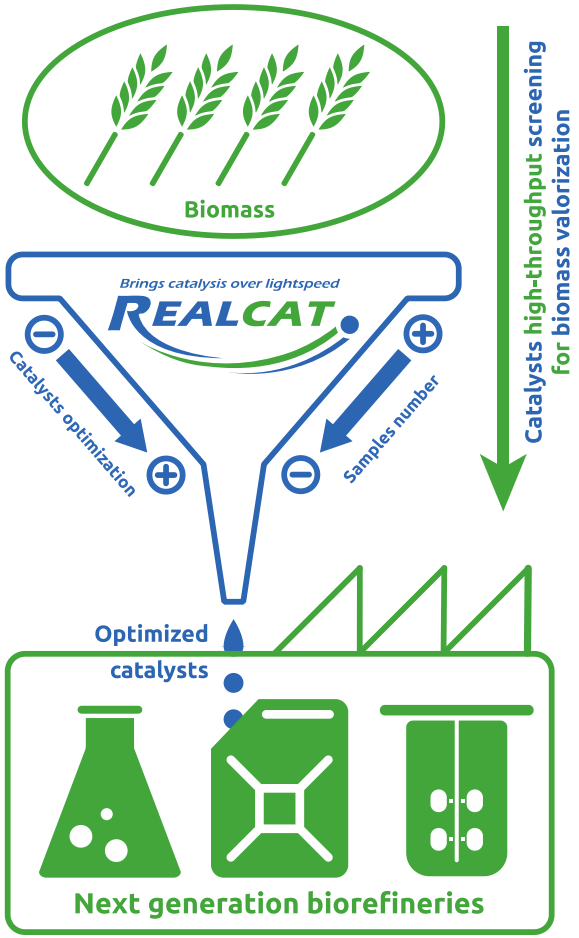
  - Synthesis
  - Characterization
  - Testing of the catalytic performances

  - Homogeneous catalysts
  - Heterogeneous catalysts
  - Biological catalysts

  } **New concept: Hybrid catalysts**

- Our goal
  - accelerate the discovery/optimisation of new catalytic processes

What is REALCAT ?



REALCAT: A collaborative project

- A collaboration between 3 labs of the same campus:
  - Unit of Catalysis and Solid State Chemistry (UCCS)
  - Bioprocesses, enzyme and microbial engineering (ProBioGEM) – Research Team of the Charles Viollette Institute
  - Centre de Recherche en Informatique, Signal et Automatique de Lille (CRIStAL)

REALCAT: Funding

- Funded by the French government in the frame of the PIA “Plan d’Investissements d’Avenir” – EQUIPEX - ANR
  - Global budget: 8.7 M€ for 10 years
  - Equipment: 6.5 M€
- Supplementary funds by FEDER (700 k€) and Centrale Initiatives Foundation (10 k€)

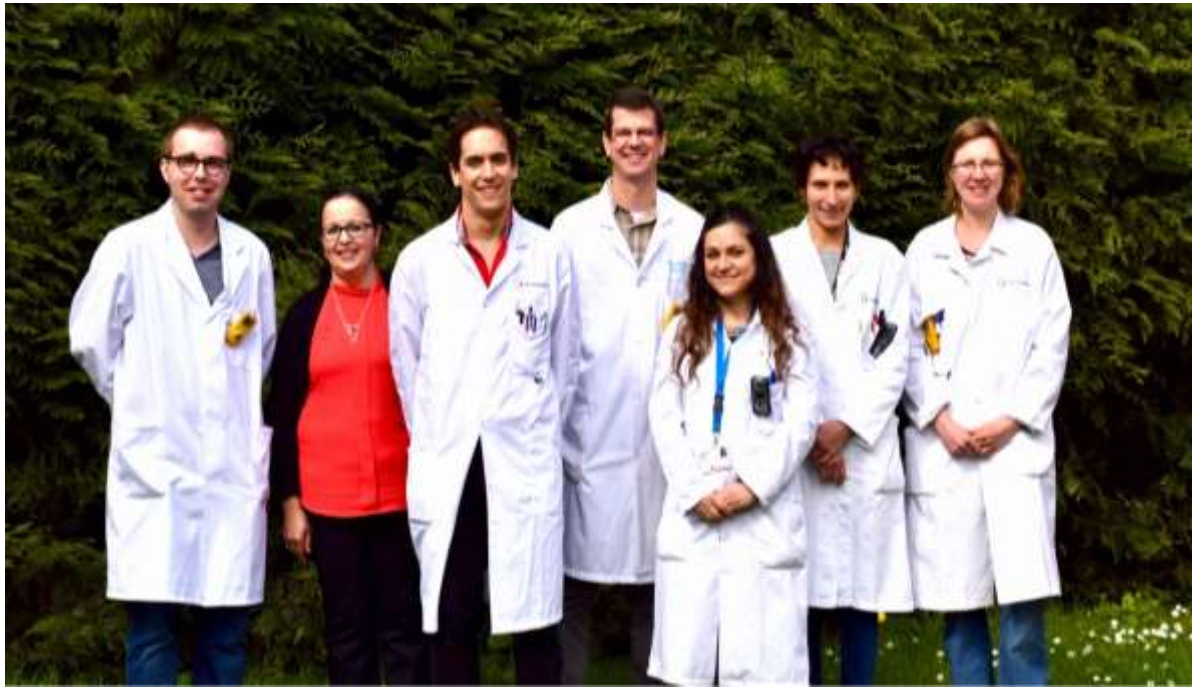
- Location: Centrale Lille, Villeneuve d’Ascq, France

The REALCAT team

- General coordinator: Prof. Sébastien Paul (UCCS)
- Expert in biomass valorisation: Prof. Franck Dumeignil (UCCS)
- Experts in biocatalysis: Prof. Pascal Dhulster, Prof. Philippe Jacques, Prof. Vincent Phalip and Prof. Renato Froidevaux (ProBioGEM team of the Charles Viollette Institute)
- Experts in data treatment: Prof. Philippe Vanheeghe, Prof. Cédric Lhoussaine (CRIStAL)

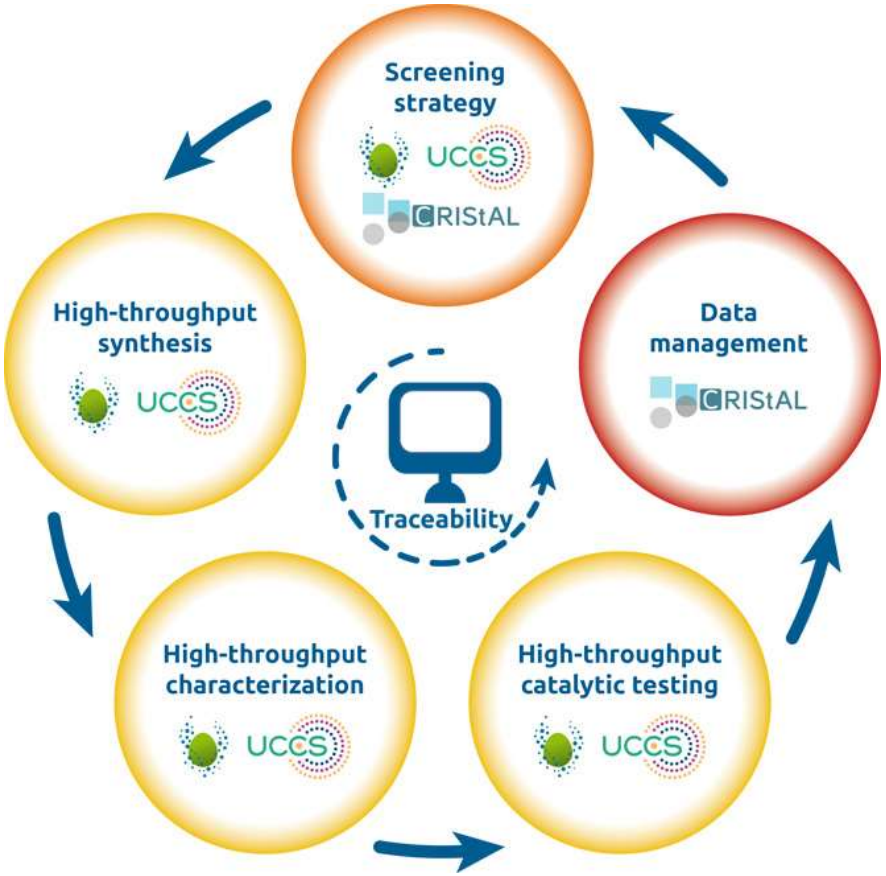
The REALCAT team

- The REALCAT operational team



From left to right: Julien Poulain (tech.), Zohra Gueroui (secretary), Dr Egon Heuson (Research Eng.),Prof. Sébastien Paul (Coord.), Dr Joëlle Thuriot (Eng.), Dr Svetlana Heyte (Research Eng.) and Dr Pascale Dewalle (Eng.)

REALCAT: a multidisciplinary approach



HT tools for catalysts synthesis

- 2 fully automated Chemspeed platforms for coprecipitation, impregnation and hydrothermal synthesis
- MBraun glove-box for homogeneous catalysis
- Robot for HT synthesis of biocatalysts by cell culture
- Robot for HT synthesis of biocatalysts by technology of directed evolution of proteins
- Molecular Devices Colony Picking System

HT tools for characterization

- Bruker XRD
- Bruker XRF
- Bruker IR
- Horiba Raman
- Agilent ICP

All of them are HT tools to keep the efficiency of the whole workflow!

HT tools for catalytic testing (1/3)

- 3 Flowrence units from Avantium for gas phase testing
  - 16 reactors each with on-line GC analysis
  - 2 units equiped with cold traps

- Chemspeed platform equipped with 8 reactors (autoclaves) for liquid phase testing at high pressure (80 bars)

- Chemspeed platform equipped with 36 reactors for liquid phase testing at ambiant pressure

HT tools for catalytic testing (2/3)

- Freeslate Screening Pressure Reactor (SPR): 24 batch reactors in //

- Teamcat Solutions Multi-R

HT tools for catalytic testing (3/3)

- M2PLABS Biolector: microplate-based fermentation system (48 wells) with on-line monitoring of pH, dissolved oxygen and biomass

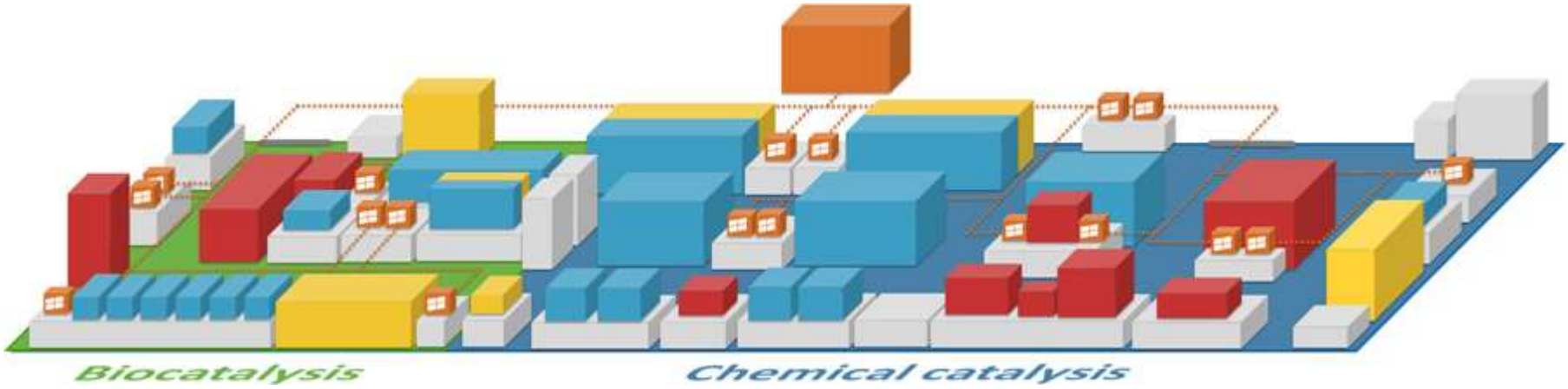
- 500 mL instrumented fermentors in // (6) for the screening of biocatalytic properties

HT tools for offline analysis

- Shimadzu Fast-GC 2010 (FID and MS)
- Shimadzu LC-GPC 2020 + Wyatt detector for polymers
- Shimadzu LC-MS 2020 simple quad for light molecules

- Waters LC-TOF for heavy molecules
- MALDI-TOF for heavy molecules

REALCAT implementation scheme



- Roughly 30 equipment installed the last two years
- Central server to collect the data issued from all the equipment

Keyword: Safety & Confidentiality

- 3 levels of gas detection
- Venting system
- HP gas distribution network
- …

- Closed network
- Crypted data
- Limited access
- …

Modalities of use of REALCAT

- The REALCAT equipment is open to worldwide external users (academic and industrial) in the frame of:
  - internal projects
  - academic collaborative projects
  - industrial collaborative projects
  - pure provisions of services

SCIENTIFIC PRODUCTION

- **2 patents filed (+ 2 others in progress)**
- **1 book chapter**
- **15 articles in international journals with high IF**
- **8 invited seminars**
- **More than 70 students trained on REALCAT since 2013**
- **1 PhD co-financed**
- **Creation of the TEAMCAT SOLUTIONS start-up**

TEAMCAT
SPEED UP YOUR CATALYSIS

ACKNOWLEDGEMENTS

For the financial and administrative support

The REALCAT platform is benefiting from a state subsidy administrated by the **French National Research Agency (ANR)** within the frame of the 'Future Investments' program (PIA), with the contractual reference 'ANR-11-EQPX-0037'. **The European Union**, through the **ERDF** funding administered by the **Hauts-de-France Region**, has co-financed the platform. **Centrale Lille**, the **CNRS**, and **Lille 1 University** as well as the **Centrale Initiatives Foundation**, are thanked for their financial contributions to the acquisition and implementation of the equipment of the REALCAT platform.


Thank you for your kind attention
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Brings catalysis over lightspeed
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