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PhD Proposal 2019

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Title: NEW TECHNOLOGY FOR BIOFUEL PRODUCTION FROM RECYCLED CATALYTIC MATERIALS

Scientific field: MATERIALS SCIENCE, PROCESS, CATALYSIS
Key words: NANOCOMPOSITES, MECANOCHEMISTRY, CATALYSIS, MODELISATION

Details for the subject

Background, Context:
With the implementation of the EU-wide Energy-Climate Package aiming to achieve a 20% share of renewable energy by 2030 and a 20% reduction in greenhouse gas emissions compared to 2000, all industrial sectors are called upon to put in place more sustainable and environmentally friendly means of energy production. Biomass is the third largest primary energy source in the world after coal and oil and has the greatest potential for renewable energy. The thermochemical conversion of biomass into natural gas of renewable origin (bio-SNG) by gasification/methanation [1,2] appears today as a solution with high potential and complementary to the current uses of biomass. However, the biomethane industry generates a large amount of waste catalysts that need to be constantly regenerated. This regeneration targets the combustion of coke surrounding the catalyst that is produced during the reaction. The catalyst regeneration process emits CO2, a limiting factor to environmental awareness. This regeneration step is long, expensive and extremely polluting for a clean fuel production approach. The objective of this project is to implement a new "Green" technology for the recycling of catalysts without solvents, CO2 emissions or thermal treatment for biofuel production.
Research subject:
The dry process coating process is a very promising technology [3,4,5] for the production of new materials without solvents or thermal treatment. Thus, the recycling of the catalysts will be carried out in a high-energy mixing process that will generate mechanical shear stresses to create new particles with modified properties and/or functionalities. Dry coating consists in depositing a new active phase layer (Nickel, Cobalt, etc.) on the surface of the deactivated catalysts to form fine particles (nanoparticles) by applying mechanical forces (shear, impacts, etc.). The small size of the active particles allows a better adhesion due to the van der Waals forces [6]. The particles are then brought to adhere to each other to make a new catalyst. Thus, each time the catalyst is deactivated, a new coating will be processed. This technology will allow a waste and costs reduction. The type of coating obtained by this process depends on different parameters related to the particulate system (e. g. size, shape, density, roughness, surface energy of the particles or their chemical nature), as well as parameters related to the process used (type of apparatus, operating conditions of velocity, time, temperature and filling rate). Depending on these factors, the coating can be classified into categories: discrete coating, continuous coating, film coating and embedding. Continuous coating can be in the form of a layer of particles (single-layer or multi-layer), porous or in continuous film.

Work plan:
This project represents an innovative catalytic recycling solution for the bio-SNG industry adapted to environmental protection conditions. This work focuses on the development of a “solvent free” process for catalytic recycling solution based on an innovative breakthrough technology. The program of this thesis is structured around the following items:
- Implementation of a green "mechanosynthesis" process for the creation of new functional materials with controlled physical, mechanical and reaction properties for methanation.
- Understanding and modelling the phenomena related to physico-chemical interactions during coating
- Identification of the operating conditions for active phase deposition via mechanochemistry
- Optimisation of catalytic performance of these novel materials for converting syngas to biomethane
- Extrapolation of the green process to a pilot scale.

References: