PhD Proposal 2017

School: CentraleSupelec, Université de Paris Saclay	
Laboratory: LGPM (Chemical Engineering and Materials)	**Web site: http://www.lgpm.ecp.fr/**
Team: Materials and bio-based materials	**Head of the team: Prof. M.L. Giorgi**
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Collaboration with other partner during this PhD: **In France:**	**In China:**

Title: Effect of particle size of biomass on the production of bio-liquid and syngas for energy purpose
Scientific field: Biomass, Biofuel, Downstream processing, Spectrometry
Key words: Biomass, torrefaction, GCMS, HPLC, biofuel, bio-gas, modelling

Background, Context:

Increase of energy demand leads to a fossil fuel reserves reduction and serious environmental pollution associated to non-sustainable growth. In order to solve these problems, many investments have been made developing renewable energy and alternative fuels. Among the renewable energy and alternative fuels, plant-based raw materials (i.e. biomass) are one of the most attractive resources as substitutes of a large fraction of fossil resources as feedstock for industrial productions.

Biofuels are developed worldwide since last few decades. One promising way to produce this kind of biofuel is gasification followed by a Fisher-Tropsch synthesis. The increasing interest in biomass as a source of renewable energy gives rise to a crucial requirement to grind the raw product to ease storage and transport, to concentrate the energy content. Due to the resilience of lignocellulosic products and the energy consumed during grinding, a pretreatment is needed for a direct use in gasifier. However, there are yet some efficiency limitations on the treatment intensity and particle size of the feedstock.

In our team, preliminary experiments have been performed on thermal treatment of different biomass [1,2]. The treatment including torrefaction, pyrolysis and gasification helps improving the higher heating value and grindability of biomass. In addition, mass loss has been found as a criterion in identifying the treatment intensity strongly correlated with biomass elemental composition as well as energy properties. The heats of reaction are also a key point for the process control, as heats of reaction are likely to produce thermal overshoots [3]. However, we also observed that for the same treatment, the mass loss quite significantly depends on the particle size, probably due to condensation of volatiles inside large particles. **This effect is a key point for the optimization of the industrial process**. This is why our group is keen to further investigate the effect of particle size of raw biomass on the production of bio-liquid and syngas for energy purpose.

The doctorate project proposed here, based on a rigorous scientific approach, is of a highly applied and pragmatic nature, focused on the increasing need for renewable energy. At a scientific level, the successful candidate will perform thermal treatment of woody (and other plants) biomass of different sizes and treatment intensities with continuous measurement of mass, gas production and heat flux. Subsequently, the obtained products will be characterised using a complete set analytical methods. Downstream processing techniques and the use of TG-MS/HPLC are also expected to be part of the project. A modelling approach capable of prediction is also part of the project. This part will take advantage of the excellent skills of our team in computational modelling and guarantees that the outcomes of this work could be applied to upscale the process up to the industrial level.

Research subject, work plan:

Thermo-chemical degradation

The work will initially concentrate on temperature of thermal treatment (T) and treatment duration (D) for achieving the optimal T-D capable of efficient syngas and bio-fuel production with different sizes of biomass feedstock. A first-rate thermo-balance (ATG) with modulated DSC, coupled to GC-MS will be used to analyse the mass loss, the heat flux and the volatiles continuously during the thermo-chemical treatment. Subsequently, the solid residues will be characterised using several analytic tools, such as elementary analysis, specific surface (BET), UHPLC…

Bio-liquids

During the second part of the project, the work will concentrate on the downstream processing of bio-liquids. This last step is the higher challenging part of the project and would use the academic network of the LGPM laboratory to gain access to high-powered analytical tools such as HPLC-MS. It is anticipated that the majority of the work would be performed using the latest analysis apparatus since the preliminary studies have already been completed. The study will be very dependent on the progress during the first, second and third part of the project and will consist of a search to identify the bio-compounds and, understand clearly thermal treatment mechanisms of biomass for bioenergy use.

Up-scaling

LGPM already developed a computational tool to predict the heat treatment of a whole set of particles. This tool is suitable for upscaling up to the industrial scale. All kinetics and heat fluxes measured during the first stage will be analysed using an inverse method [4] to propose a set of reaction parameters to feed the dual scale computational code [5]. We currently work on a DEAM formulation (Distributed Activation Energy Method), which proved to be very robust in the prediction when used for varying time/temperature pathways.

This PhD program, well balances between scientific content and applications, would suit a motivated graduate with ambitions to meet the challenges of using and optimising updated technology in biofuel production and who is equally keen on downstream processes.

Related references of the host team

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