Entrained flow gasification of bio-oil for synthesis gas

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Biomass-based transportation fuels are envisaged to become crucial to substitute traditional fossil fuel derived transportation fuels, the more so because fossil fuels add to the greenhouse effect. Apart from direct routes (extraction of rapeseed, ethanol through fermentation, or upgrading of bio-oil by thermochemical processes), indirect routes include the production of synthesis gas ('syngas') as an intermediate. The use of such biomass based transportation fuels offers the significant advantages of the near zero emissions of air pollutants including greenhouse gases from fossil fuels, and its contribution to a more sustainable development world-wide.

Syngas is mainly produced by gasification of natural gas, coal and occasionally from heavy oil residues. Usually, the gasification process is operated at high pressures, up to 40 bar, and temperatures of 800 up to 1400^{o}C. The produced syngas, after cleaning and conditioning, can be easily used for synthesis of fuels (alcohols such as methanol, or diesel through Fischer-Tropsch). Renewable sources, such as biomass, are promising alternatives to fossil feedstocks for syngas production, because of the wide availability throughout the world, and the near zero CO_2 emissions from renewable fuels. Compared to the use of fossil fuels for syngas production, biomass materials offer the additional advantage that it already contains a substantial amount of oxygen (> 50 wt.%), avoiding the need to add large amounts of high-cost pure oxygen (approx. € 60,-/ton fossil fuel) For comparison, 0.9 ton oxygen is required for 1 ton coal or approx. 0.7 kg syngas, versus approx. 0.3 ton oxygen per ton bio-oil or approx. 0.8 kg syngas (?=0.18). Bio-oil as a feedstock for syngas, with further processing to transportation fuels, offers unique features, especially if compared to the route of solid biomass gasification:

- it can be used as a co-feed in existing, large-scale, high pressure, entrained flow gasifiers;
- the ease of handling (storage, very fine oil atomisation and pressurisation);
- its improved properties, such as its homogeneity, uniformity and consistency, and
- the simple logistics and cheap transport for a liquid.

The present paper discusses the pre-competitive and applied research for the gasification of wood-derived bio-oil in an entrained flow reactor to produce syngas, which can be further processed to synthetic liquid fuels. Experimental results are reported that will give insight and understanding of the technical and economic potential of entrained flow bio-oil gasification for syngas production, including results on:

1. The bio-oil characteristics required for gasification in an entrained flow gasifier.
2. The atomisation of the bio-oil.
3. A small entrained flow reactor (approx. 10 kW_{th}), with special emphasis on the contaminants level of the gas (e.g. tars and alkali metals).
4. The optimal operating conditions for thermal bio-oil gasification,
5. The requirements for syngas cleaning and conditioning, and
6. A technical and economic evaluation of the proposed system.