Iron and nickel nanoparticles dispersed in biomass derived solid fuel : Study of a new catalytic way to enhance hydrogen production and tar destruction efficiency in gasification processes

Y. Richardson[1,2], J. Blin[1], G. Volle[1], L. Van De Steene[1] and A. Julbe[2]

[1]CIRAD-PERSYST, UPR Biomasse Energie, TA B-42/16, 73, avenue J.-F. Breton, 34398 Montpellier, Cedex 5, France
[2]Institut Européen des Membranes UMR 5635 CNRS/ENSCM/UM2, CC47, Place E. Bataillon, 34095 Montpellier, Cedex 5, France

Introduction

Biomass gasification is one of the most promising options for converting biomass to bioenergy or 2nd generation biofuels. However, one of the main bottlenecks in these processes is related to the low H_2/CO ratio and the high tar content in the produced gas which significantly exceeds the required syngas specifications for either Fischer-Tropsch synthesis or high temperature fuel cells applications. The techniques required for gas conditioning are costly and reduce overall energy efficiency.
Catalytic cracking / reforming is currently one of the most effective ways to reduce the syngas tar content at relatively low temperature[1]. Carbon deposition often deactivates the catalyst and reduces its lifetime[1-2]. Actually, further studies are still needed to develop novel catalyst formulations and/or new strategies.
The aim of this study is to form dispersed metal nanoparticles inside the wood matrix and to assess the efficiency of this innovative catalytic way in the pyrolytic decomposition of wood, pyrolysis being the first thermochemical transformation which occurs in biomass gasification processes. It is expected that metal nanoparticles will optimize hydrogen rich syngas production and allow in-situ catalytic craking and reforming of nashent tars. Iron and nickel were selected because of their well known activity in the concerned reactions[1-3] and their ferromagnetic behavior allowing to consider easy catalyst recovery and reuse through magnetic separation.

Results and discussion

Metallic iron and nickel nanoparticles were formed within the lignocellulosic matrix of beech wood by a two-step procedure : adsorption of metal cations by the wood particles through metal precursor impregnation in aqueous solution and pyrolysis of the resulting modified wood particles. The adsorption of the metal cation and the formation of metal nanoparticles during pyrolysis has been studied by attenuated total reflection FTIR spectroscopy, X-ray diffraction (XRD) (fig. 1), scanning electron microscopy (SEM) (fig. 2), thermogravimetry and differential thermal analysis. A mechanism of metal nanoparticles formation is proposed.

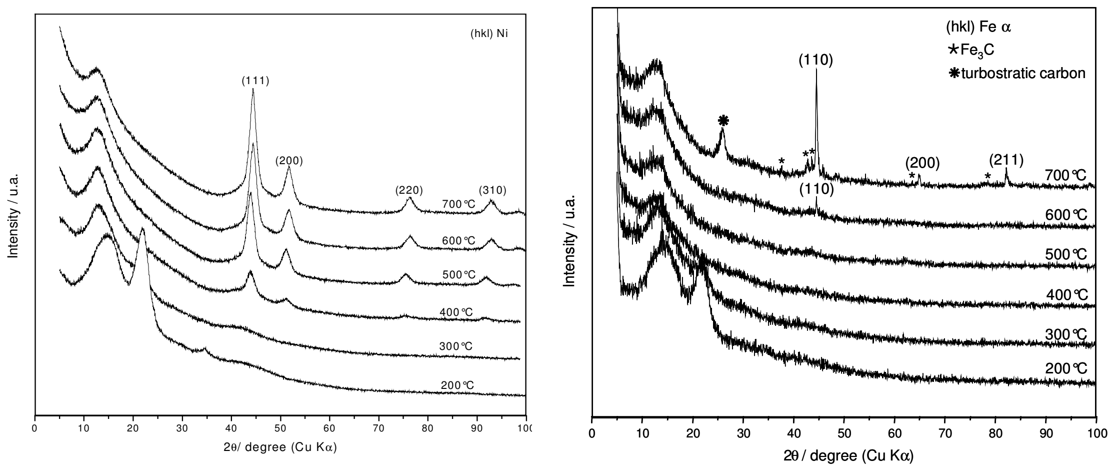

Fig. 1 : XRD patterns of Ni/C and Fe/C samples obtained at different pyrolysis temperatures.

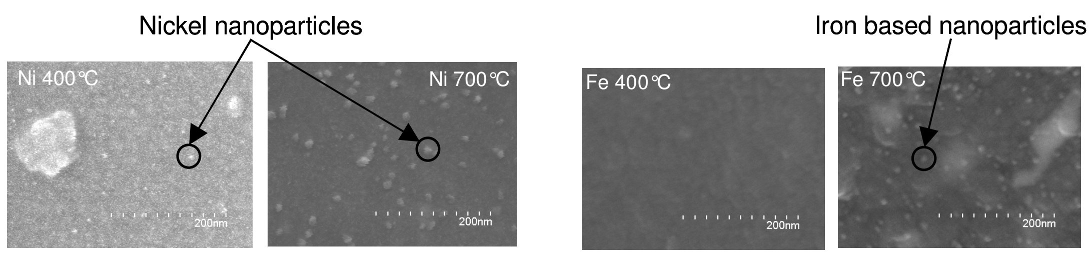

Fig. 2 : SEM images of Ni/C and Fe/C samples obtained at 400 and 700°C.

The catalytic activity of iron and nickel nanoparticles for hydrogen rich syngas production during wood pyrolysis has been studied in a pyrolysis reactor equipped with a gas chromatograph allowing analysis of evolved gases.

References

1. R. Coll, J. Salvadó, X. Farriol, D. Montané, Fuel Process. Technol. 74 (2001) 19.
2. D. Sutton, B. Kelleher, J. R.H. Ross, Fuel Process.Technol. 73 (2001) 155.
3. K. Polychronopoulou, A. Bakandritsos, V. Tzitzios, J.L.G. Fierro, A.M. Efstathiou, J. Catal. 241 (2006) 132.