論文 / 著書情報
Article / Book Information

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Title(English)	Production of syngas and bio-oil by fast pyrolysis of biomass using Sn-Bi molten metal with Ni-based catalyst
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Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	Chemical Science and Engineering	系コース	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of	（Engineering）
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要旨（和文 2000 字程度）
Thesis Summary（approx.2000 Japanese Characters）

The objective of this work is to study the effects of molten metal media and its catalytic enhancement by a heterogeneous catalyst on biomass fast pyrolysis with regards to syngas and bio-oil production. We proposed to use a tin-bismuth (Sn-Bi) molten metal as a heat transfer medium for biomass pyrolysis. It is non-toxic, thermally stable, has low melting point, high boiling point, high heat capacity and thermal conductivity. It is also relatively low cost. Ni-based catalyst was used for the enhancement of both the biomass liquefaction and gasification and was expected to exhibit great selectivity towards the aimed products in each process. In this study, we first confirmed the effectiveness of the suggested media for the biomass pyrolysis at low heating rates. Then, the effects of high heating rate at high and low temperatures were investigated for the biomass pyrolytic gasification and liquefaction, respectively. Hydrogen injection was applied for the hydro-deoxygenation of pyrolysis vapors to upgrade the produced bio-oil. Lastly, the enhancement mechanism of the heating medium was proposed and validated.

Chapter I: Introduction. The background and importance of biomass recycling were briefly explained for basic understanding. The principles of the biomass fast pyrolysis that included pyrolytic gasification, liquefaction, hydrotreatment, and factors affecting the product distribution and efficiency were explained. Molten metal as an advantageous heating medium for the pyrolysis was described, along with the review of relevant research works in the field and current state of the technologies. The proposal of the catalytic enhancement for the pyrolysis and a review of suitable catalysts for maximizing the yields of the target products were presented. A novel medium for an efficient biomass fast pyrolysis was proposed, the objectives for the research were set, and the structure of the thesis was presented.

Chapter II: Biomass gasification in non-preheated media, describes and discusses the experimental study of cellulose pyrolysis in non-preheated media in a reactor, which provides low heating rate conditions. The performance of the proposed media was evaluated with regards to the enhancement of the gasification. As a gradually heated system, the evolving gases were simultaneously analyzed to observe cellulose decomposition pathways with and without the catalyst. Molten metal capability to improve heat exchange and Ni-catalyst enhancements of gas production and hydrogen selectivity were experimentally investigated. Factors that affect the pyrolysis including the medium, the ratio of metal to cellulose, the ratio of catalyst to metal, temperature, and heating rate were studied, and optimum parameters were established. This study set the course and conditions for further work with biomass conversion into gaseous and liquid products presented in *Chapters III and IV*, respectively.

Chapter III: Biomass gasification in preheated media, verified the feasibility of the utilization of molten metal and its combination with the catalyst in a practical way. The conditions such as temperature and

the loading of the biomass were based on the previous chapter results. The proposed media were preheated to the gasification temperature and the extent of the gasification for cellulose and aspen wood were tested. Rapid heating of the feedstock in the hot media resulted in sudden volatilization of the biomass. Catalyst ability to lower the pyrolytic gasification temperature and alter the product gas composition was proven. The stability of Ni/Al_2O_3 catalyst for the continued use in the combination with the preheated molten metal was experimentally confirmed.

Chapter IV: Biomass liquefaction in preheated media, describes the experimental study of the biomass fast pyrolysis at lower temperature than the gasification with an aim of the bio-oil production. Preheated media effect on liquid yields were confirmed and compared against the results obtained during hydrogen injection. Bio-oil yields and its compositions at different pyrolysis conditions were analyzed. The fast heat transfer in the molten metal promoted cracking reactions, and as a result improved the liquid yield from the biomass pyrolysis, and lowered the average molecular weight of the bio-oil. Hydrogen injection upgraded the bio-oil with the assistance of the catalyst, which promoted deoxygenation and hydrogenation reactions.

Chapter V: Enhancement mechanism and conceptual process design, discusses the phenomena governing the pyrolysis of the biomass and proposes the mechanism of the enhancement by the molten metal and catalyst medium. Thermogravimetric analysis was performed to confirm the pyrolysis pathways in different media, also to prove the improvement of the feedstock reactivity due to high heating rate. Theoretical model of heat transfer from the molten media to the biomass was applied to the conditions of this study. The predictions were compared to the experimental results. Conceptual process design was proposed using the data obtained from the previous chapters.

Chapter VI: Conclusion, summarizes the findings obtained from this study, and provides future prospects. A novel medium of Sn-Bi molten metal for biomass fast pyrolysis was proposed and was studied with regards to syngas and bio-oil production. Different temperatures and heating conditions were applied to evaluate the performance of the proposed medium, understand the enhancement mechanism, and establish the optimum operating conditions. The proposed medium was proven to greatly enhance the heat transfer during biomass fast pyrolysis. Ni/Al_2O_3 catalyst in the medium improved H_2 selectivity during the gasification, and aided the hydro-deoxygenation of the bio-oil with hydrogen injection.