Preface and Thesis Organization

The literature revealed that the catalytic properties of solid catalysts are strongly affected by the preparation method, production conditions, and quality of source materials. In addition, catalysts synthesized via MOFs are effective and stable for many industrial applications. Therefore, in this research, the whole focus would be on developing a chemical method to synthesize a wide range of nano-sized porous structures catalysts via MOF. Catalyst's porosity mainly depends upon the preparation method. Highly ordered structures possess sequence of building blocks which inherit multiple channel and high porosity—these unique structures of the catalysts favorable for various chemical processes.

This work will enable the development of a chemical process to synthesize a wide range of supported monometallic and heterometallic catalysts via MOF for environmental and green energy applications. In addition, the findings of this work will add useful information to available literature for steam reforming of organic compounds and possibly fill the gap required to transform MOFs-based catalysts in this area. There are several important areas where this study will make an original contribution to both industries and human development. It is anticipated that this study will provide an exciting opportunity to advance the researchers' knowledge about the heterometallic materials via MOFs and will cause to open new research avenues in this field.

The main limitation of this work is the lab-scale development of a chemical process to produce heterometallic catalysts. Developing a new process or a new material at a lab-scale is the first step before scaling up applications. However, obtaining the required features remains a challenging task with scaling up, particularly in case of nanomaterials. For example, the physical and chemical properties of nanoparticles differ when produced in

bulk. This is because the process conditions, such as mixing, temperature, pressure, etc., are difficult to maintain at larger-scale production than lab scale.

Another potential problem is that the evaluation of the catalysts will be carried out against model compounds of bio-oil "acetic acid." For the whole bio-oil, the conditions were different, and coking might be more in case of bio-oil. Therefore, there may be a chance the developed catalyst will not meet efficiency as noticed at the lab scale.

Thesis organization

This thesis is written in the article style format using the guidelines of the department of chemical engineering Indian Institute of Technology BHU, Varanasi, India. The present This thesis consists of five chapters, including the introduction and literature review, experimental work, and their possible results, divided into three sections of chapter IV dealing with different aspects relevant to the topic of the study. In addition to the following chapters' descriptions concerning covered objectives and activities carried out.

Chapter 1:

This chapter deals with the current energy and its demands and issues related to the consumption of present energy resources. It also includes a brief introduction to the research and objectives of the study.

Chapter 2: The current Chapter deals with the exhaustive literature review. The use of bio-oil as a renewable source of hydrogen production. The various technologies for the production of hydrogen and its advantage and its disadvantage. Since the present study aims at the efficient and stable conversion of bio-oil to hydrogen, the catalyst modification strategies to enhance catalyst activity and stability during steam reforming of acetic acid for hydrogen production were studied.

Chapter 3: This chapter includes the materials and details of the experimental procedure, like the description of the experimental set-up, synthesis of support (ALC), MOFs derived Ni precursor and preparation of catalysts used in this study. This chapter also includes the different characterizing techniques.

Chapter 4: This chapter divided into three sections:

Section I: The current section is aimed at the synthesis of catalysts via two different precursors. Their catalytic activity and stability were evaluated in AASR for hydrogen production at different temperatures.

Section II: The current chapter focused on the catalytic activity, stability and coke deposition behavior of the catalysts synthesized via MOFs precursors. The catalytic activity were tested for acetic acid steam reforming with different Ni loading x% Ni (x = 10, 15 and 20 wt%) at fixed operating conditions (S/C = 6.5, WHSV = 1.05 h^{-1} and,) with varying temperatures from 400 to 650 °C.

Section III: This chapter discussed the detailed study on the performance of this 15% Ni-complex/ALC catalyst for AASR. Effects of operating conditions such as temperatures (400 - 650 ºC), steam to carbon molar ratio (S/C, 0 to 6.5) and WHSV (0.6 to 2.35 h^{-1}) were evaluated and optimized.

Chapter 5: In the last, the major outcomes of every chapter are summarized, followed by the recommendation of the current research work. After that, the references which have been cited in the entire thesis are presented.