

Aneta Magdziarz, PhD, DSc, Prof. AGH
AGH University of Science and Technology
Mickiewicza 30, Av.
30-059 Krakow, Poland
e-mail: amagdzia@agh.edu.pl, phone no +48 12 617 50 47

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Review of Doctoral Dissertation

“Improving in corrosion, transportation and storage properties of real waste derived pyrolysis oil”

Author: Fekhar Bahmed

Supervisor: Norbert Miskolczi, PhD, Prof.

University of Pannonia, Faculty of Engineering

MOL Department of Hydrocarbon and Coal Processing

The doctoral thesis presented by Fekhar Bahmed is entitled “Improving in corrosion, transportation and storage properties of real waste derived pyrolysis oil” and was completed under the supervision of Prof. Norbert Miskolczi at the University of Pannonia in Hungary.

Due to the environmental protection and the elimination of fossil fuels in the production of electricity and heat, the use of renewable energy sources and the application of wastes are priority directions. Especially in the last twenty years, European Union countries, have been pursuing an intensive energy and climate policy promoting the use of renewable energy sources and thermal utilization of wastes. Municipal solid wastes are one of the most important energetic feedstocks to produce fuels. Solid biomass – mainly forestry, and wood and agricultural residues covers more than two-thirds of the biomass market in Europe. According to article 3 of the EU Directive "Binding overall Union target for 2030", the EU member states have endorsed the achievement of a binding minimum 32 % share of renewable energy consumption. Waste-to-energy methods include conventional technologies, e.g. direct combustion, and advanced conversion technologies like pyrolysis, gasification, and liquefaction. One of the most promising and innovative technology of waste thermo-chemical conversion to receive easy-to-use forms of energy is pyrolysis. Depending on the process

parameters the different share of products and composition yields is obtained. The enhanced quality of the products can be achieved by using catalysts as additives.

Selecting the utilization of wastes via pyrolysis, to obtain high quality of oil, as the subject of doctoral research proves awareness of the current problems and challenges of thermal conversion processes of solid wastes. Therefore, it confirms the importance of chosen research topic and the appropriately targeted scientific interest of the PhD student. Additionally, the presented research plan brings relevant input and as well as it has a significant practical potential and addresses a new and important aspects of pyrolysis of wastes under catalyst presence. Therefore, the novelty and scientific level of this thesis is very high, considering the crucial of research subjects like: wastes utilization, production of oil, corrosion, transportation and storage properties of oil as a fuel and a substrate for chemicals production.

This dissertation is well organised. Its 132 pages include abstracts (in English and Hungarian), a list of abbreviations, 5 main chapters (preceded by a brief introduction and ending with summary), and actual references (293 positions). Introduction part presents the motivation and main aims of the work. Author defines the goals and scope of the work. It should be emphasised that Fekhar Bahmed presents many chemical reaction equations, tables, figures and graphs which make this work more readable and comprehensive in its presentation of information and knowledge.

The first chapter, entitled: Literature summary includes the state-of the art concerning waste polymers, its thermal processes focusing on pyrolysis process and oil production. In Introduction chapter Fekhar Bahmed had proved that he deeply studied and understood the properties of pyrolysis oil and reflected of them problems like corrosion, aging and transportation. This thesis contains scientific background related to the topic and Author can analytically and critically elaborate the literature. The literature review is very credible and compact based on more than 200 references. PhD student has proved that despite many studies concerning stability improvement of waste derived pyrolysis oil it still requires more investigation in this field and the application of catalysts to increase the yield is a big challenge. Moreover, long-term storage, transport and stability parameters of pyrolysis oil are not well known, thus studies of these issues are right.

Chapter 2 is dedicated the Experimental part. Firstly, the studied feedstocks (waste plastic, biomass and paper) and catalysts are described giving its basic parameters. Next, PhD student presents used bench-scale reactors (two kinds), and procedure of applied analytical methods for further investigations. The application of wide spectrum of instrumental

techniques and procedures confirms good scientific background and experimental experience of PhD student. The chosen methods are suitable for examining these objectives. At the end of this chapter research plan is presented in the form of graph, but in my opinion it is confusing and not clear. Additionally, it is not explain why the 500-550 °C temperature range was selected as the pyrolysis temperature. Please explain.

Chapter 3 presents the Results of experimental studies and Discussion. This part contains huge amount of results (5 sub-chapters). Fekhar Bahmed had studied many cases of experiments including the influence of bench-scale reactor, kind of feedstock and catalyst on the products quality. PhD student presents the characteristic of gases, light oil and heavy oil, and finally corrosion and aging tests for all investigated cases. Author had analysed which catalyst improves the yields of gas and light oil and what kind of benefits for process they give. Based on obtained experimental results the analysis of the process parameters was done in proper way. Unfortunately, there are presented many results under many parameters. From one side it is the advantage of this thesis, but sometimes it is difficult to find main conclusions. It should notice that Author compares his own results with the literature.

The chapter 4 includes Conclusions presented in compact way. The Table 4.1 presents the most significant results obtained under different reaction parameters which can be very helpful in reading and understanding the presented topic.

The doctoral dissertation ends with Summary. There are presented the general outcomes and future perspectives referring to the main aims of the thesis. The summary contains a list of the most important conclusions resulting from the research carried out within this work. Finally, Fekhar Bahmed presents a research plan for the future.

Concluding, this doctoral thesis represents a high scientific level of work. It presents very interesting and original topic for scientists working on wastes pyrolysis and oil properties. All experiments were well and adequately arranged and analytical techniques were correctly applied. It is noteworthy that the executed work had provided a new point of view for corrosion, transportation and storage properties of pyrolysis oil.

To sum up, it would be worth seeing if the PhD student could refer to the issue of how he sees the future of waste utilization via pyrolysis process, is it possible to implement this data to real scale reactors? What factors, in Autor's opinion, will mainly determine the direction of wastes pyrolysis development?

I would like to confirm that Fekhar Bahmed's doctoral dissertation is of scientific novelty, with its extensive range of research, good presentation and discussion of obtained results. Moreover, Fekhar Bahmed's scientific achievements are confirmed by papers

published in highly ranked scientific journals (Journal of Cleaner Production, Chemical Engineering Transactions, Journal of the Energy Institute, Journal of Environmental Management) and international conference attendances. PhD student had showed his scientific maturity, laborious and skills of planning, conducting experiments and solving problems.

In my opinion, the reviewed doctoral thesis fulfils all requirements posed on theses aimed of obtaining a PhD degree. This thesis is ready to be orally defended, in front of the respective committee.

A handwritten signature in blue ink, appearing to read "Allegolm".