

Answer to Prof Dr Aneta Magdziarz

First of all, thank you a lot for the Reviewer's work and the questions/comments, which help me to improve the scientific content of the PhD thesis. The questions/comments were answered from point to point. Please see the answers below.

1. How do you see the future of waste utilization via pyrolysis?

Firstly, the progress in the scientific research on different polymer waste pyrolysis, can facilitate the commercialization of those technologies. There are companies in various countries, including Germany, Japan, Taiwan, Thailand, India, and Malaysia that are presently implementing, or considering the approval of pyrolysis plant. Additionally, many private companies are offering expert services on pyrolysis technologies to their clienteles in several countries (e.g. Waste4Me (Netherlands), GECA Environment (Canada)). Furthermore, there is a great opportunity that polymer recycling policies via pyrolysis will be integrated into the national waste minimization plans for several countries in the near-term future. However, the compliance with strict quality requirements for pyrolysis oil is an important consideration. Therefore, further development in pyrolysis processes is needed to reduce the contaminants and improve the stability of products.

2. Is it possible to implement this data to real scale reactor?

Based on the obtained results, it would be possible to implement the data into real scale-up reactor. However, further research should be done in order to mitigate the effect of unexpected impediments.

3. What factors will mainly determent the direction of waste pyrolysis development?

- *Since waste sorting is not sufficient, the development of the technologies that process effectively a mixed waste stream is considered as a necessity.*
- *Feedstock supply and logistics is crucial while scaling-up. For instance, transportation distance is a significant factor to study in order to minimize the cost and the environment impact of the waste collection.*
- *In order to attend an economically feasible process, the scale-up is increasingly becoming an important area of research.*
- *As the pyrolysis process is an endothermic reaction and appropriate heat transfer has to be delivered to meet the process heat requirements. Heat transfer within the reactor is an area of concern in the case of pyrolysis. Therefore more attention on the reactor design should be carried out.*
- *Due to the pyrolysis oil physical and chemical properties, which are different from the conventional petroleum fuels, the pyrolysis oil requires new norms and standards that have to be established.*
- *Amending the legal framework in order to suit for the new type of oil (pyrolysis oil).*
- *Governmental subsidies is needed to stimulate the thermal recycling of waste by pyrolysis.*

- *Improvement in the basic chemical and physical properties of pyrolysis oil, such as longer storage time, lower viscosity, and lower solids content to make it more competitive and more attractive in the market.*
- *The future research should be focused on exploring new techniques of using pyrolysis oil for fuels, energy, and chemicals production.*
- *Close cooperation between the industry and university should be focused on.*