**CHAPTER 5**

**CONCLUSION AND SUGGESTION FOR FUTURE WORKS**

### 5.1 Conclusion

In this research, a laboratory scaled microwave plasma reactor for plasmochemical conversion of solid waste was designed, constructed and tested. Microwave plasma assisted pyrolysis of RDF and its components were investigated. This research combined the plasma reactivity and pyrolysis process with a high heating rate that favored hydrocarbon cracking. The experimental runs were carried out with a 800W microwave power, operated at atmospheric pressure and variable carrier gas flow rate in the range of 0.50-1.25 lpm. The carrier gas flow rate was the important parameter. It influenced on the plasma characteristics, such as plasma temperature, discharge length, power density, product gas and obtained char evolutions. The plasma temperature reached maximum at 1578K with 0.75 lpm argon flow rate and 28.1 W/cm$^3$ power density. The increasing carrier gas flow rate increased the discharge length and volume, and resulted in decreasing power density, therefore higher microwave input power was required for stable plasma generation. The required input power density for this reactor was approximately up to 35 W/cm$^3$. Increase in proximate and elemental composition of the solid residues of all materials were evident as a result of carbonization. The decreasing of volatile matter was the indication of complete plasma process and high conversion of hydrocarbon material to gaseous fuel. The reduced fraction of volatile matter in RDF was about 86%.

Hydrogen and oxygen contents were reduced. The reduced fraction of hydrogen and oxygen contents of RDF were about 73%, and 69%, respectively. The fixed carbon of chars was found to increase significantly, compared to that original in the starting materials. The increased fraction of fixed carbon of chars was found to be averaged at 81%. Significant degree of carbonization appeared to take place under non-thermal plasma environment. The products of plasmochemical conversion of RDF is gas, char, and liquid. They were about 75, 16, and 9%w/w, respectively. Carbon conversion efficiency of RDF was about 79%. Average char yield of RDF and its HHV were 24% and 39 MJ/kg, respectively. The obtained chars may be used as active carbon after further upgrading. The finding was of practical interest for the utilization of hydrocarbon material for the purpose of char production. Major components of product gas generated were CO, $H_2$, $CH_4$, $CO_2$ and $O_2$. The averaged product gas mass of waste paper, biomass, PE, and RDF were 3.72, 2.51, 2.30, and 6.02 g, respectively. They were found to initially increase with increasing argon flow, reaching maximum value at flow rate of 0.75 lpm. At this flow rate, the use of RDF as feedstock generated 13.79% $H_2$, 65.47% CO, and 3.99% $CH_4$, respectively. Heating value and gas yield of product gas of RDF were 11.17 MJ/m$^3$ and 1.01 N-m$^3$/kg, respectively. After which, they were markedly reduced at higher carrier gas supply rate. Within the range of flow rates considered, average total content of combustible fractions in the product gas of all feed stock was 79.76%, and of RDF was 79.60%, which can be used as fuel gas. This is of practical interest for utilization of solid wastes for the purpose of fuel gas production. The averaged energy efficiency plasmochemical conversion of waste paper, biomass, PE, and RDF were about 50%, 35%, 32%, and 60%, respectively. The energy efficiency was found to initially increase with increasing argon flow, reaching maximum value at flow rate of 1.0 lpm. Maximum energy efficiency of plasmochemical conversion of RDF was about 66%, and energy from gas product was 0.095 MJ.

Numerical model of gaseous fuel production from plasmochemical conversion of solid waste was investigated. The model was modified from gasification thermodynamics equilibrium model of Syed et al., (2012) and model of Jarungthammachote et al., (2006). The equilibrium relations for pyrolysis and gasification reactions were investigated using water-gas shift and bouduard reactions. The equilibrium constant used a Standard Gibbs function of formation. The model showed lower $CO_2$ yields and higher $H_2$ and $CH_4$ than the experiments. The root mean square error (RMSE) of product gas composition from the equilibrium model were calculated to be less than 5.

**5.2 Suggestion for Future Works**

Based on the results, analyses and reviews of literature, the following are my suggestions for advancing the research on plasmochemical conversion of solid waste.

1. Plastic is inappropriate with plasmochemical reactor in this research because it generated melted plastic film into the quartz reaction tube wall. The film was interrupted microwave radiation, that affected to plasma stabilization.

2. Tar interrupted the microwave radiation, that also affected to plasma stabilization. Raw material with low tar or without tar content such as hydrocarbon gaseous may be used as feedstock for future work.

3. Properties of feedstock are essential to the development of effective thermodynamic equilibrium model which can predict product composition.