CHAPTER V

CONCLUSIONS AND RECOMMEDATIONS

5.1 Conclusions

The dielectric-barrier discharges reactor exhibited another feasible means of activating the methane molecules for initiating its conversion. The reactions are achieved by the collisions between high energetic electrons, released from the metal electrode, and the methane molecules inside the discharge gap to form higher hydrocarbons. From the experimental results, conclusions could have been drawn as follows:

1. An increase in the external voltage supplied to the reactor caused an increase in the energy, on an average basis, of the electrons and part of these charged particles induced in the discharge gap. This, therefore, became more successful in attacking the methane molecules and thus converting them into the active species suited for the reactions.
2. Upon a decrease in the reaction residence time, the likelihood of every methane molecule to find the electrons which have sufficiently high energy for breaking its C-H bond would be decreased. This, consequently, resulted in a remarkable drop in its conversion.
3. A variety of products produced from this methane plasma reaction consisted of ethane, propane, butane, ethylene, some traces of unsaturated C_4-hydrocarbons and hydrogen. Since the commercial values of all of these products are clearly higher than that of the

starting methane itself, thus it leads to a conclusion that this plasma reaction can enhance the methane upgrading without any loss of the existing carbon atoms into those undesired carbon oxides products as observed in the case of oxygen addition.

4. Even though the methane conversion was found to be significantly affected by the applied voltage in this study, the selectivity of its products was, however, nearly independent to the change of this parameter.
5. Two alternative methods of applying the voltage were also found to have an influence on the behavior of the methane conversion. Nevertheless their product selectivities were nearly the same.
6. Helium may also exhibit a synergistic effect to enhance the reaction of methane. It would have to be noted, however, that this effect was invariably influenced by the relative amount between the helium and the methane molecules. With the unsuitable ratio of methane-helium present in the feeding mixture, the dilution effect of the helium molecules could become more predominant.
7. The presence of ethane with methane in the feed was found to exhibit a significant improvement in the methane conversion. The selectivities of ethylene, propane and butane were found to be greatly enhanced. The increase in these selectivities were expected to be related to direct dissociation of the ethane molecule under the electric discharges environment.
8. By the accompany of ethane with methane into the feed, the formation of propane was proposed to be occurred via the direct coupling between the C_2 species and C_1 species. Whereas the pathways leading to butane formation could be described by both the direct coupling of the C_3 species with C_1species and the coupling of two C_2 species.

9. From the case of ethane-helium and propane-helium feeding system, the cracking reaction of the desired higher hydrocarbon products into smaller molecules was also found to be possible under the discharge environment. The degree of this decomposition reaction was observed to be increased with the increasing voltage.

5.2 Recommendations

From the experimental results, it can be stated that the degree of methane conversion was quite low while the residence time was too long to gain considerable methane conversion. Hence, it is obvious that an improvement in the efficiency of this dielectric-barrier discharges reactor should still have to be employed.

Another interesting point that is needed to be investigated further is about the effect of the different voltage rising approach on the methane reaction behavior. In addition, to extend the knowledge about this methane plasma reactions, the effect of propane should also be investigated. The combination between the data of this present work and any quantitative results that may be derived from those future work may lead to a new advanced technology in upgrading methane and natural gas commercially.