CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

5.1.1 Optimum temperature for calcination of photocatalyst

In order to achieve the proper nanocrystalline photocatalyst, the optimum temperature for calcination of photocatalyst was determined. The following results are concluded since preparation of photocatalyst till the optimum temperature was obtained.

- Nanocrystalline TiO_2 with particle sizes of 15-80 nm for anatase phase and 100-200 nm for rutile phase had been successfully synthesized by a simple modified sol-gel method using PVP and TIAA as starting materials and at the calcination temperature in the range of 500-900 °C for 3 hours.
- The optimum calcination temperature for the nanocrystalline TiO_2 to achieve the highest photocatalytic degradation of phenol was 600 °C as influenced by the fraction of anatase to rutile of 92.5:7.5.
- Despite degradation efficiency of the nanocrstalline TiO_2 was lower than the commercial TiO_2, the sample calcined at 600°C presented a smaller amount of intermediates throughout the phenol degradation than that of the commercial TiO_2 sample.

5.1.2 Optimum Ratio of Titanium and Tin for Nano-photocatyst

After the nanocrystalline TiO_2 was prepared, the addition of tin was made in order to make the composite photocatayst called as nano-photocatayst. The optimum ratio of titanium (Ti) and tin (Sn) was accordingly determined and summarized as follows.

- Addition of Sn promoted higher surface area, but in the mean time it accelerated phase transformation of anatase to rutile.

- Different calcination temperatures yielded the different characteristics that influence the photocataytic degradation. At 600 °C calcination, as increasing the percentage of Sn doping, the surface area and the rutile phase was increased. While at 550 °C calcination, the percentage of Sn doping did not much show the effect on transforming of anatase-to-rutile, but only made the increment of surface area.
- The optimum conditions to synthesize TiO_2 were 2 % mixing of Sn by mole of Ti and heat treatment at 550 °C for 3 hours. Nano-photocatalyst is abbreviated as TiO_2/Sn2.

5.1.3 The Occurrence of Photocatalytic Reaction's Intermediates

Intermediates of the synthetic phenolic compounds both individual and mixed solution were determined on the photocatalysis with TiO_2/Sn2. and commercial TiO_2. The studied phenolic compounds were phenol, guaiacol and syringol. The results are concluded as below.

- All of photocatalysis of the studied phenolic compounds presented none to two intermediates produced when using TiO_2/Sn2. While two to three intermediates were produced when using the commercial TiO_2. It was possibly due to the surface reaction of phenolic substances on tin oxide that the dehydrogenation step was expected. Therefore, the free hydroxyl groups are less than the one without tin. The reaction taken place at the hydroxyl group would be less, leading to less number of intermediates.
- Both of the synthesized and commercial ones produced hydroquinone which is considered as harmful to environment. However, after completing degradation of the main phenolic compound, all intermediates would be substantially disappeared.

5.1.4 Photocatalytic Degradation of Phenolic Compounds

After obtained all optimum conditions, the phtocatalytic degradation of phenolic compounds of the individual and mixed solution were carried out. Comparison of the synthesized and commercial photocatalysts was made as the results summarized as follow.

- The degradation of individual phenol, guaiacol and syringol solution with the synthesized TiO_2/Sn2, the sequence of higher degradation were syringol>guaiacol>phenol. While the commercial TiO_2 presented the degradation in the reverse order with TiO_2/Sn2 as phenol>guaiacol>syringol.
- The degradation of mixed phenolic compounds solution by TiO_2/Sn2 and commercial TiO_2 had the same degradation order as syringol>guaiacol>phenol.
- Photocatalytic degradation of the individual and mixed phenolic compounds by the synthesized TiO_2/Sn2 and the commercial TiO_2 were significantly different in terms of consistency. The TiO_2/Sn2 presented the consistency of phtocatalytic degradation of both individual and mixed phenolic compound solution. It also presented the highest degradation efficiency of methoxy phenol.
- The commercial TiO_2 presented the inconsistency of the degradation between the mixed and individual compounds. The commercial one presented the higher degradation for the individual solution of phenol. The phenol degradation efficiency was substantially decreased for the mixed solution.

5.1.5 Photocatalytic Reaction: Pulp and Paper Wastewater

The real wastewater from pulp and paper mill was used for photocatalytic degradation. The results are briefly presented as below.

- Initial concentrations of phenolic compound in the pulp and paper wastewater were 0.0235, 0.3613 and 0.2097 mg/l for phenol, guaiacol and syringol respectively.
- After 6 hours irradiation, the remaining contents of phenol, guaiacol and syringol were 51 %, 51 %, and 58%, respectively for the commercial TiO_2. The remaining content of phenol, guaiacol and syringol were 87%, 25%, and 37%, respectively for TiO_2/Sn2. Both commercial and synthesized ones could not perform well on phenol degradation in the mixed phenolic compound solution. This is possibly due to the irradiation time was not long enough
- The synthesized TiO_2/Sn2 likely exhibited the better performance for the mixed phenolic compounds in real wastewater as indicated by the higher

degradation of methoxy phenol (guaiacol and syringol). This performance was the same as the results obtained from the synthetic mixed phenolic compound solution.

5.2 Recommendations

Recommendations are as follows.

- Improvements of the batch reactor by re-design to provide a longer time for photocatalytic degradation. Increasing the irradiation contact of a solution with the light by lowering the depth of water in reactor may increase the efficiency of phenolic compound degradation. Immobilized photocatalyst on the fixed surface of a reactor (thin film application) is other factor to be considered.
- Reducing an agglomeration of the synthesized TiO_2 should be improved by modifying the synthesis process.
- Preaparation of photocatalyst by other methods for example precipitation method, solvothermal method, microemulsion method, etc.
- It should extent the study to other dopants to synthesized TiO_2 such as CdS, ZnO, etc.