CHAPTER III

RESEARCH MODEL

This chapter presents research model, dependent variable definition and unit of measure, independent variables definition and unit of measure, and selected research question.

3.1 Research Model

The objective of this research is to remove lignin from teak veneer to improve its color quality using combinations of enzymes and hydrogen peroxides stated in chapter I. The underlying theory and previous works reviewed in chapter II are selected and adapted to develop research model.

According to Tsai et al. and Mackey et al. previous work reviewed in chapter II, lignin has been indicated as one of the major component in wood (Mackey et al., 1997; Tsai et al., 1998). Tolen et al. indicated that lignin affected the color of papers. Therefore, lignin has been selected as a dependent variable in this research model (Tolan et al., 1997).

Hampp stated that hydrogen peroxide can be used to remove lignin in pulps but the amount required is large thus make the process economically unfavorable since it is expensive (Hampp, 2001). Hampp, Kirk, Suurnakki et al., and Tolan et al. as reviewed in chapter II suggested the use of enzymes (Hampp, 2001; Kirk, 1996; Suurnakki et al., 1997; Tolan et al., 1997). The enzymes and hydrogen peroxide are; therefore selected in this study to improve the color quality of teak veneer from commercially grow teak.

Two different category enzymes are selected as the first and second independent variables of the research model of this study.

Hydrogen peroxide is selected as the third independent variable of the research model of this study. Although, hydrogen peroxide is not as toxic as chlorine, it is still a chemical and it is a strong oxidizing agent; therefore, the amount of hydrogen peroxide used should be minimized.

Time is an important factor in industry. The process that took a long time to accomplish cannot be applied in industry. Time; therefore, is selected as the fourth independent variable in this study.

Enzymes, hydrogen peroxide and time are independent variables. Their combinations at various conditions are used to study their effects on the removal of lignin, the dependent variable in this study.

See Figure3.1 for the research model used in this study.

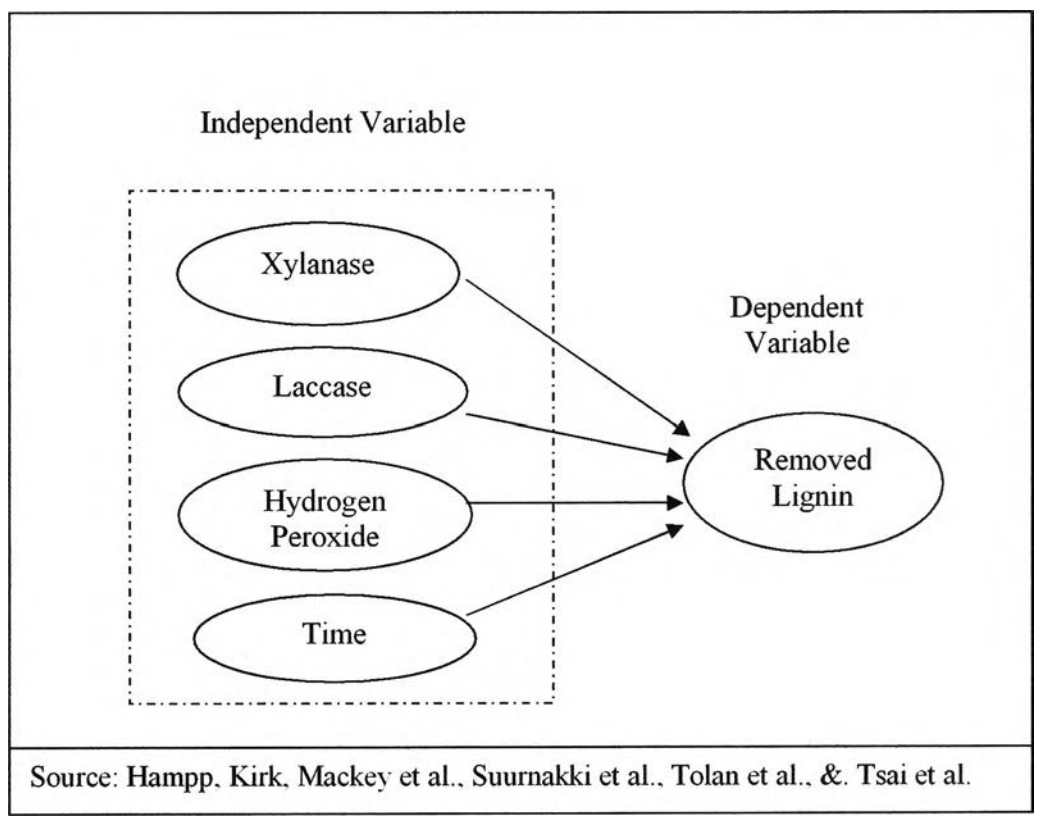

Figure 3.1 Research Model

3.2 Dependent Variable Definition and Unit of Measure

The dependent variable in the research model of this study is lignin. As review in chapter II, lignin is a complex aromatic polymer and a major nonpolysaccharide component in wood (Campell, 1991; Tsai et al., 1998). Lignin is composed of guaiacyl lignin, or G lignin, and syringyl lignin, or S lignin.

The direct measurement of lignin content in teak veneer is excluded from this study due to the fact that the method disintegrates the sample and it measures the lignin content of the whole sample not the required surface lignin. The use of indirect measurement using image processing technique is employed. Materials concerning image processing technique are presented in Appendix A. The wood samples are scanned before and after the experiments and calculated for their average gray scale, the differences between the before and after gray scale are calculated as % change in gray scale. See appendix C on calculating average gray scale and percent change in gray scale (% Δ gs). The unit of average gray scale of a veneer sample is defined as gray scale per pixel. The unit of measure of removed lignin is the % change in gray scale. The higher the percent increase in gray scale, the lighter the color of the wood sample becomes, which means the higher the lignin removed.

3.3 Independent Variables Definition and Unit of Measure

Xylanase is the first variable in this study. Xylanase is an enzyme that attack xylan. The unit of measure of xylanase is unit per millilitre. The range of xylanase concentration used in the experiment is 0.05, 0.25, 0.5, 1 and 2.5 unit per millilitre. Xylanase unit definition: One unit will liberate 1 micromole of reducing sugar measured as xylose equivalents from xylan (X0627) per min at pH 4.5 at 30°C

Laccase is the second variable in this study. Laccase is an enzyme that degrades lignin. The unit of measure of laccase is unit per millilitre. The range of laccase concentration used in the experiment is 0.05, 0.25, 0.5 and 1 unit per millilitre.

Laccase unit definition: One unit will produce a ΔA_{530} at 0.001 per min at pH 6.5 at 30°C in a 3 millilitre reaction volume using syringaldazine as substrate.

Hydrogen peroxide is the third variable in this study. The unit of measure for hydrogen peroxide is its concentration in percentage. The range of hydrogen peroxide used in the experiment is 2%, 5%, 8%, 10%, 15% and 20%.

Time is the fourth independent variable in this study. Time is defined as the time used to remove lignin from teak veneer from commercially grown teak. The unit of measure for time is hour. The range of time used in this study is 0.5, 1, 2, 4 and 24 hour.

3.4 Specific Research Questions

Referring to research question number three in chapter I and research model in this chapter, the specific research questions to be investigated in this study are presented as follows.

Specific Research Question 1:

Do xylanase, laccase, hydrogen peroxide and time have significant effect on lignin removal from teak veneer?

Specific Research Question 2:

Does the combination of xylanase, laccase, hydrogen peroxide and time have significance effect on lignin removal from teak veneer?

If the experimental outcomes support the specific research question, the next specific research question to be addressed is as follow.

Specific Research Question 3:

What levels of xylanase, laccase, hydrogen peroxide concentration and time affect the amount of lignin removed from teak veneer?

The third specific research question is concerned with effect of different levels of xylanase, laccase and hydrogen peroxide concentration, and time on the amount of lignin removed.

3.5 Chapter Summary

In this chapter the research model was picked. The dependent variable was chosen to be the removed lignin. The independent variables were selected to be the concentration of xylanase, laccase and hydrogen peroxide, and time. Their unit of measure was defined. In the case of lignin removal, since the direct measurement cannot be applied, the indirect method of measurement the gray scale of the samples was chosen instead. Finally the specific research questions to be investigated in this study are presented.