Journal of Applied Sciences

ISSN 1812-5654

Journal of Applied Sciences 7 (15): 2076-2079, 2007
ISSN 1812-5654

Bonding Analysis of Amino Resin Wood Adhesive with Pesticide Using Response Surface Method

Awang Bono, Mariani Rajin and Nancy Julius Siambun
Chemical Engineering Programme, School of Engineering and Information Technology,
Universiti Malaysia Sabah, 88999 Kota Kinabalu, Malaysia

Abstract: Wood base industries are among the dominant players in Malaysia economic activities. In this research, by using Response Surface Method (RSM), studies of bonding between Disodium Tetraborate Decahydrate (DTD) pesticide and various formulation of wood adhesive i.e., Melamine-Urea-Formaldehyde (MUF) resin is carried out. The RSM formulated twenty-five MUF formulations, consisting combination of different amount of formaldehyde, melamine, urea added in stage-1 and stage-2 of resin synthesis and DTD pesticide. The liquid products of resin are then hardened and tested using Fourier Transformation Infra-Red (FTIR) and visible spectrophotometer (VIS), to analyse the bonding of the resin and pesticide. The data from the FTIR and VIS analysis were then compiled and analysed using Response Surface Method. The results show that, different amount of the formaldehyde, melamine, urea and DTD pesticide, gives specific impact to the strength of MUF resin-pesticide bonding.

Key words: Melamine-urea-formaldehyde, disodium tetraborate decahydrate

INTRODUCTION

MUF resin is an amino resin, which widely used as binder for various wood products such as plywood, particle board, fibre board and decorative laminate. MUF resins and adhesives are classified as thermosetting polymers and are produced by a condensation reaction between melamine, urea and formaldehyde (Emery, 1986). These MUF polymers can be formulated to provide various degrees of water and weather resistance for use in exterior, humid and indoor climate. Added variation in viscosity and reactivity give these resins a wide application area, greatly exceeding that of UF resins (Pizzi, 1994).

In order to preserve plywood or veneer from being attack by termites, fungi and other microorganism, so in this research, MUF resin is developed and added with pesticide to produce wood adhesive with capability to kill the wood deteriorating agents. The pesticide used in this research is Disodium Tetraborate Decahydrate (DTD). This type of pesticide is less toxic to human. DTD has been used to control insects' stomach and thus the insect cannot absorb nutrients and it will stave to death. To produce a safe killing pest, it is important to study the leachability of the pesticide from the MUF resin.

In producing MUF resin containing DTD pesticide, there are four main components i.e., melamine, urea, formalin and DTD pesticide. Thus, it is possible to build different types of formulation based on the different composition of each component. In such case, Response Surface Method (RSM) is chosen to find the ideal process settings to achieve optimal performance of resin.

This research is to study the application of Response Surface Methodology in the determination of the designed laboratory to observe the reaction between Disodium Tetraborate Decahydrate (DTD) pesticide and Melamine-Urea-Formaldehyde (MUF) resin.

MATERIALS AND METHODS

Synthesis of Melamine-Urea-Formaldehyde (MUF) resin: The method applied in the synthesis process of MUF resin was adopted from Awang *et al.* (2003a and b) and Nancy *et al.* (2003). The process was divided into three stages i.e., initial process, polymerisation or refluxing process and post-refluxing process.

In the initial process, 37% concentration of formaldehyde, melamine, urea and DTD were mixed homogeneously with a stirrer at a speed of 350 rpm. The final product was a mixture of white-coloured solution. In order to inhibit the fast polymerisation of the mixture, the pH of the mixture was adjusted between 8.8 to 9.0. This was achieved by adding a few drops of 40% concentration sodium hydroxide. Within a period of 50 to 60 min, the mixture temperature was gradually increased until it reached a temperature of 88°C, to optimise the polymerisation process.

Corresponding Author: Awang Bono, Chemical Engineering Programme, School of Engineering and Information Technology, Universiti Malaysia Sabah, 88899 Kota Kinabalu, Sabah, Malaysia Tel: +6088-320000/3027

In the polymerisation process, refluxing was continued until it reached the end point in approximately one and half hours to two hours. The end point was determined by dropping the mixture into a beaker of water at a temperature between 30 to 40°C. The formation of a whitish streak from the droplets indicated that the end point had been reached (Pizzi, 1994).

In the post-refluxing process, once the end point had been achieved, the resin was cooled down to 65°C. Subsequently, an additional urea was poured into the mixture. During this post-refluxing process, the pH of the mixture was kept constant between 8.5 to 9.0 by adding sodium hydroxide. Finally, the mixture was cooled to 40°C.

After the cooling process, 1% of ammonium chloride was added to a 20 g of MUF resin to transform the resin into solid form. Ammonium chloride is a hardener which can transform the resin from liquid form to solid form. The hardened resin was then kept for leaching analysis and a thin film of hardened MUF resin was prepared for Fourier Transformation Infrared (FTIR) analysis.

Binding analysis of MUF-DTD with Fourier Transformation Infrared (FTIR): In this research, solid form of MUF resin (dried analyte) is tested using FTIR. The B-O functional group in the FTIR peak indicated the effective bonding or strength of bonding between MUF resin and DTD. If the percentage of B-O peak intensity is high, therefore the effective bonding or strength of bonding between MUF-DTD is low. To determine the strength of MUF-DTD bonding in different type of solvent (water, 10% ethanol and 30% ethanol), the percentage of B-O peak intensity before and after soaking in solvent was recorded and compared. The soaking process was carried out for two weeks. Figure 1 shows the comparison of FTIR peak between MUF resin sample with and without 10% ethanol as solvent.

Comparison of Leachability of DTD from MUF Resin: The liquid resin product is hardened by adding 1% of ammonium chloride with 105°C temperature. The solid matters were soaked in 100 mL distillation water for a period of two months. The water sample is tested every week by using visible spectrophotometer to determine the concentration of DTD that leached out from the resin. Subsequently, the solution containing DTD/water is analyzed by using quinalizarine method (Association of Official Analytical Chemist, 1990). The absorbance of which can be measured spectrophotometrically at 620 nm (Bassett *et al.*, 1978).

RESULTS AND DISCUSSION

Binding Analysis of MUF-DTD Using FTIR: MUF-DTD resin films were tested with FTIR before immersing it in solvents. The B-O functional group, which shows the present of DTD bind with MUF resin is determined. It was established that the percentage of the peak intensity of the films is higher when the films was immersed in solvents compared to the films that were not immersed. This indicates that the DTD was leached out from the resin and solute in the solvents. In another word, if the DTD leach out, the binding between MUF-DTD is decreased and the strength of the bonding becomes weaker.

Figure 1 shows that the strength of MUF-DTD bonding in water as solvent is mostly affected by Melamine, urea added in initial stages (Urea 1) and DTD amount. The strength of MUF-DTD bonding is increasing when the amount of Urea 1 and DTD is decreasing and melamine amount is increasing.

Figure 2 and 3 show that the strength of MUF-DTD bonding in 10% ethanol and 30% ethanol as solvent respectively. Besides, these figures show that the

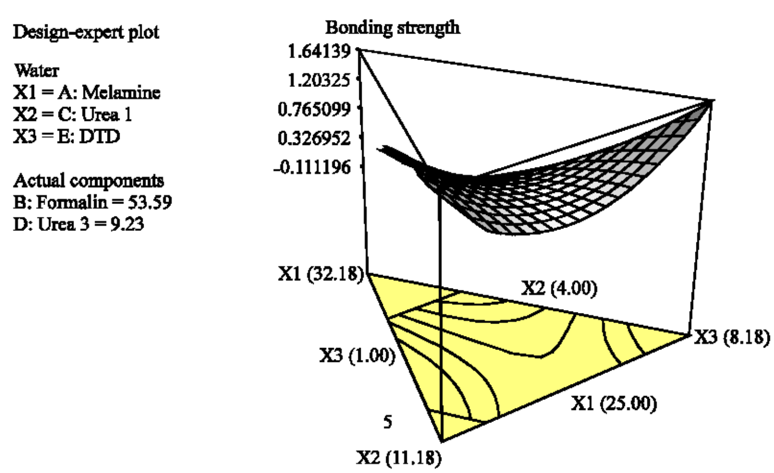

Fig. 1: Three-dimensional surface plot of MUF-DTD bonding strength in water

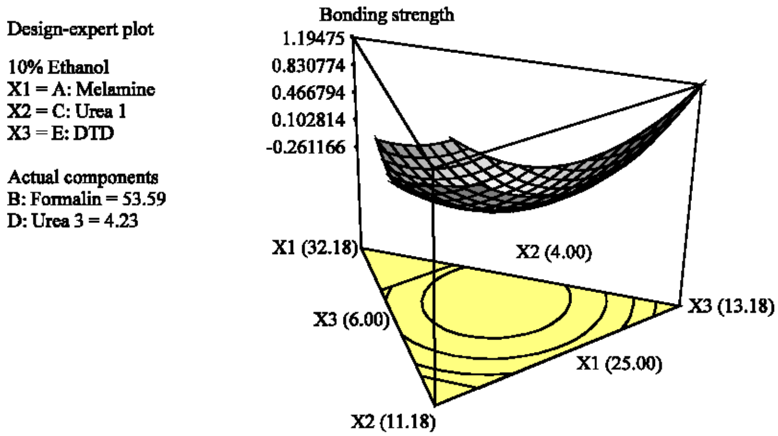

Fig. 2: Three-dimensional surface plot of MUF-DTD bonding strength in 10% ethanol

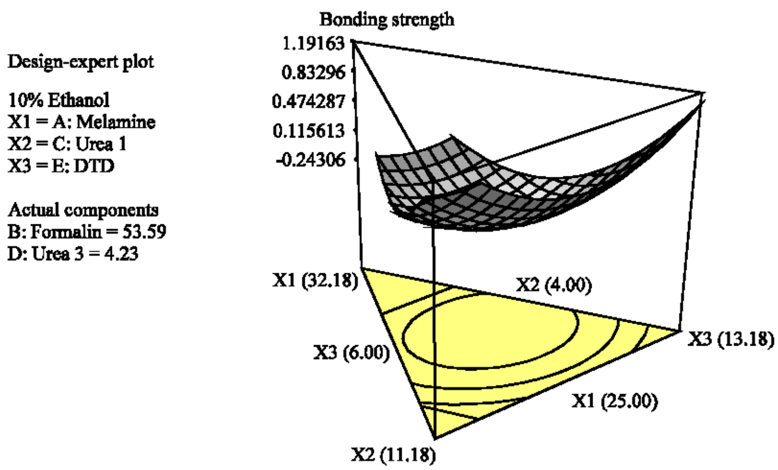

Fig. 3: Three-dimensional surface plot of MUF-DTD bonding strength in 30% ethanol

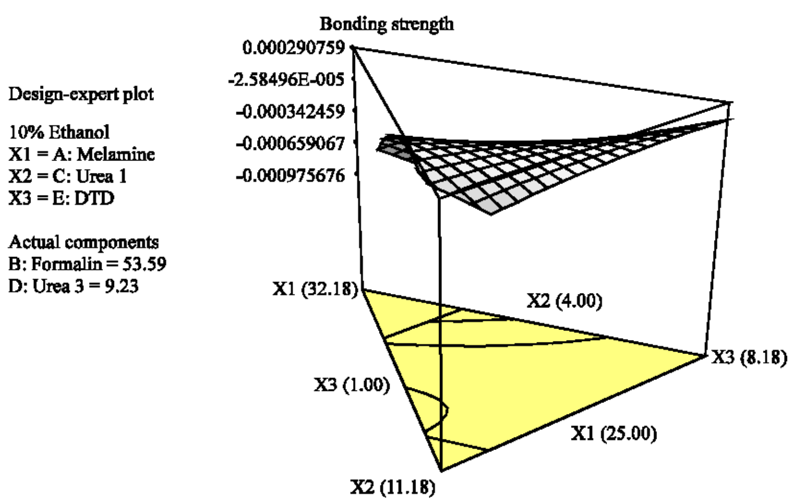

Fig. 4: Three-dimensional surface plot of the leachability of DTD from MUF resin

strength of MUF-DTD bonding is mostly affected by urea added in initial stages (Urea 1), urea added after refluxing (Urea 2) and melamine amount. The strength of MUF-DTD bonding in increasing when the amount of Urea 1 and Urea 2 is decreasing and melamine amount is increasing.

Comparison of leachability of DTD from MUF resin: In leachability testing, the higher amount of DTD leached out from the resin sample indicated the weak bonding between MUF-DTD. Figure 4 shows the 3-D surface plot of the percentage of DTD leached out from sample.

The leaching out of DTD from MUF resin is mostly affected by melamine, urea added in initial stages (Urea 1) and DTD amount. Decreasing the amount of Urea 1 and DTD and increasing the amount of melamine can reduce leaching out of DTD from MUF resin.

CONCLUSIONS

Two methods were used to test the strength of MUF-DTD bonding, i.e., FTIR analysis and determination of the concentration of the DTD leach out. FTIR results were shown to be more accurate as it can clearly detect the deference of the peak intensity compared to the leaching method. This is because the percentage of DTD leach out is too small to be detected. From the analysis, the highest percentage of leach out is 3.62% from the resin film immersed in 30% ethanol whereas the lowest percentage of leach out is 3.38% from the resin film immersed in water. Through the analysis from response surface methods, the different composition of each component like melamine, initial urea, formalin, additional urea and DTD will give different impact to the strength of MUF-DTD bonding. In FTIR analysis, the strength of MUF-DTD bonding in water as solvent is mostly affected by Melamine, urea added in initial stages (Urea 1) and DTD amount and for 10% and 30% ethanol as solvents, they are affected by urea added in initial stages (Urea 1), urea added after refluxing (Urea 2) and melamine amount. The strength of MUF-DTD bonding in water as solvent is increasing when the amount of Urea 1 and DTD is decreasing and melamine amount is increasing and for the ethanol as solvents, the strength of MUF-DTD bonding in increasing when the amount of Urea 1 and Urea 2 is decreasing and melamine amount is increasing. The leaching out of DTD from MUF resin is mostly affected by melamine, urea added in initial stages (Urea 1) and DTD amount. Decreasing the amount of Urea 1 and DTD and increasing the amount of melamine can reduce leaching out of DTD from MUF resin.

REFERENCES

Awang, B., Y.K. Beng and N. Siambun, 2003a. Melamine-Urea-Formaldehyde (MUF) resin: Effects of reaction stages and molar ratio on resin properties. J. Teknologi, pp: 38.

Awang, B., K.B. Yeo and J.S. Nancy, 2003b. Effects of Process and Formula Variation on Low Formaldehyde Melamine-Urea-Formaldehyde (MUF) Resin. J. Chem. Eng. Process, Elsevier Germany. March 2003.

Bassett, J., R.C. Denney, G.I.I. Jeffery and J. Mendham, 1978. Vogel's Textbook of Quantitative Inorganic Analysis. 4th Edn., William Clowes Limited, London.

Emery, J.A., 1986. Formaldehyde release from wood panel products bonded with phenol formaldehyde adhesives. American Chemical Society Symposium Series 316, American Chemical Society, Washington DC.

Nancy, J.S., Y.K. Beng and B. Awang, 2003. Melamine-Urea-Formaldehyde (MUF) resin: Effects of sorbitol on resin properties. Borneo Sci. J., 11: 53-60.

Pizzi, A., 1994. Melamine-Formaldehyde Adhesives. In: Handbook of Adhesive Technology. Pizzi, A. and K.L. Mittal (Eds.), Marcel Dekker Inc., New York.