XV International Conference on Durability of Building Materials and Components
DBMC 2020, Barcelona
C. Serrat, J.R. Casas and V. Gibert (Eds)

Durability Studies of Polyurethane-Based Structural Adhesives Used in Engineered Wood Products in New Zealand

Catherine L. Nicholson

BRANZ Ltd, 1222 Moonshine Road, RD1, Porirua, 5381, New Zealand,
catherine.nicholson@branz.co.nz

Keywords: *Adhesives*, *Durability*, *Degradation*, *Spectroscopy*, *Chemometrics.*

1 Introduction

The New Zealand Building Code is unique in the world in requiring evidence of a minimum durability of 50 years for all structural building elements. This prescriptive durability requirement also applies to adhesives used in structural applications such as engineered wood products (EWPs). Conventional structural adhesives based on resorcinol have a long history of use in New Zealand, providing evidence of their ability to meet stringent durability requirements. Adhesives based on polyurethanes (PURs) are used extensively in other parts of the world but with a lack of data around their performance in the preservative treated pine EWPs typically manufactured in New Zealand, it is difficult to provide evidence-based long-term durability predictions.

2 Materials and Methods

This paper is an extension of previous work carried out using attenuated total reflectance Fourier transform infrared (ATR FTIR) spectroscopy to understand the changes that accelerated ageing cause in PUR adhesives (Nicholson *et al*., 2017). FTIR spectroscopy is a useful technique for investigating PURs and has shown that they can be susceptible to hydrolysis under elevated temperature and moisture conditions (Dubelley *et al.*, 2018). In this study, the effect of hygrothermal stress was investigated through exposure of samples to accelerated ageing cycles of varying temperatures and humidities for up to 3 years. Five PUR adhesive samples were investigated, all of which had broadly similar composition as determined by ATR FTIR.

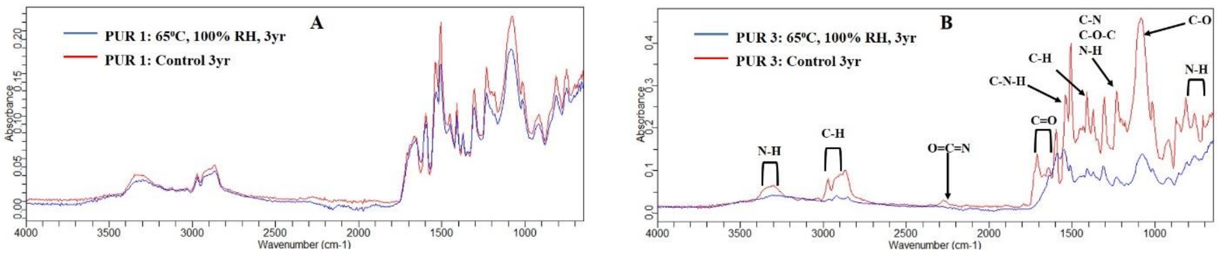

Figure 1. ATR FTIR spectra of **(A)** sample PUR 1, showing resistance to hygrothermal degradation and **(B)** sample PUR 3, showing significant hydrolytic degradation after 3 years of constant exposure to 65ºC and 100% RH.

3 Results and Discussion

Differences in spectra between control and aged samples were observed during accelerated ageing, indicating structural changes had occurred. For example, during constant exposure to elevated temperature and humidity, sample PUR 1 appeared highly resistant to hygrothermal degradation (Fig. 1A) whereas sample PUR 3 showed evidence of significant hydrolytic degradation associated with loss of the urethane structure (Fig. 1B). Spectral data were also used to build predictive models for each adhesive and accelerated ageing cycle combination. Results from cross-validation of predictive models (Fig. 2) shows potential for incorporating such models into an assessment methodology for long-term adhesive durability prediction.

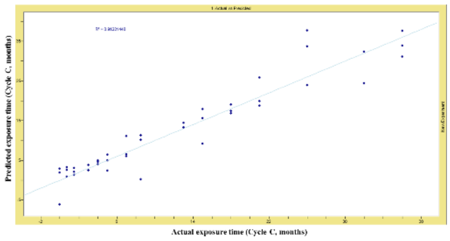

Figure 2. Cross-validation plot for the predictive model based on sample PUR 1 under constant exposure to 65ºC and 100% RH for up to 3 years' duration (R^2 = 0.91).

The wide range of PUR adhesive formulations available, and the apparent differences in resistance to hygrothermal degradation highlighted in this work, likely precludes development of a single generic test to predict the long-term durability of a given adhesive. However, the results from this work suggest that a relatively simple accelerated ageing test performed at elevated temperature and humidity over a period of several months would give an indication of the durability of a PUR adhesive to hygrothermal stress.

4 Conclusions

Spectroscopic studies of PUR-based structural adhesives can contribute important chemical information and complement other more conventional mechanical testing methodologies for durability assessment. Use of predictive models may further enhance the value of this approach.

Acknowledgements

This research is supported by the Building Research Levy.

ORCID

Catherine Nicholson: https://orcid.org/0000-0002-3541-5957

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