

## Article

# Prediction of Residual Curing Capacity of Melamine-Formaldehyde Resins at an Early Stage of Synthesis by In-Line FTIR Spectroscopy

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**Abstract:** Melamine-formaldehyde (MF) resins are widely used as surface finishes for engineered wood-based panels in decorative laminates. Since no additional glue is applied in lamination, the overall residual curing capacity of MF resins is of great technological importance. Residual curing capacity is measured by differential scanning calorimetry (DSC) as the exothermic curing enthalpy is integral to the liquid resin. After resin synthesis is completed, the resulting pre-polymer has a defined chemical structure with a corresponding residual curing capacity. Predicting the residual curing capacity of a resin batch already at an early stage during synthesis would enable corrective measures to be taken by making adjustments in the reaction conditions. Thereby, discarding faulty batches could be avoided. Here, by using a batch modelling approach, it is demonstrated how quantitative predictions of MF residual curing capacity can be derived from inline Fourier Transform infrared (FTIR) spectra recorded during resin synthesis using partial least squares regression. Not only is there a strong correlation ( $R^2 = 0.89$ ) between the infrared spectra measured at the end of MF resin synthesis and the residual curing capacity, but also the inline reaction spectra obtained already at the point of complete dissolution of melamine upon methylation during the initial stage of resin synthesis are also well suited for predicting final curing performance of the resin and a valid regression model ( $R^2 = 0.85$ ) can be established using information obtained at a very early stage of MF resin synthesis.

**Keywords:** melamine formaldehyde (MF); inline spectroscopy; process analytics; batch modelling; decorative laminates

## 1. Introduction

Melamine-formaldehyde (MF) resins have been widely used in the wood-processing industry as glues, binders and coatings for many decades due to their outstanding properties [1]. Exceptional resistance against hydrolysis and chemicals as well as remarkable mechanical properties such as high scratch and abrasion resistance make MF resins indispensable for most engineered wood products [2–5].

Since the 1950s, much research has been conducted to understand melamine-formaldehyde resins and to develop MF resins for special applications. The fundamentals are already well

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