“Cross-linking system for formaldehyde-free melamine-urea resins” - abstract

by Justyna Chrobak

Currently, urea-formaldehyde, melamine-formaldehyde, melamine-urea-formaldehyde and phenol-formaldehyde resins are still most commonly used in the production of particleboard. Due to its carcinogenic properties, the presence of free formaldehyde in resins and other industrial products has raised a great concern in recent years. Increasing public awareness and the possible tightening of legal regulations related to the use of formaldehyde are prompting wood-based panel manufacturers to seek alternatives to the currently used amine formaldehyde resins. Recent literature reports indicate that it is possible to develop new amino resins that do not contain formaldehyde. Formaldehyde substitutes include primarily glyoxal, glutaraldehyde, 5-hydroxymethylfurfural, dimethoxyethanal and others. The use of such substances eliminates the problem of free formaldehyde emission from the resin used in the production of wood-based panels. However, these substitutes are usually characterized by lower reactivity, which is why the use of formaldehyde-free resins may negatively affect the mechanical and strength properties of wood-based panels. Nevertheless, there is still a need to develop new solutions, and due to the many challenges associated with the complete replacement of formaldehyde, further research is needed, especially in the field of application of the technology in industrial practice.

The main research goal of doctoral thesis was to develop a formaldehyde-free amino resin and to select a hardener compatible with it. Based on the conducted literature study, glyoxal, glutaraldehyde and dimethoxyacetaldehyde were selected as formaldehyde substitutes. The aim of the first research task was to develop a composition and method of resin synthesis in such a way that the obtained resin was homogeneous and stable (maintained the viscosity of below 700 mPa·s for at least 7 days). In the second research task, resins meeting this condition were subjected to curing tests, first using hardeners commonly used for curing amine formaldehyde resins. Taking into account the positive effect of N-methylpyrrolidone hydrosulfate on the curing of melamine-glyoxal-glutaraldehyde resin described in the literature, parallel tests of curing the resins using various ionic liquids and eutectic mixtures were conducted. The aim of research within this task was to obtain a resin-hardener system with a curing time of less than 10 minutes.

A thermal analysis of the melamine-glyoxal resin was carried out, and the parameters of thermal and thermooxidative stability were determined. It was observed that the resin was cured thermally at about 120°C and the positive effect of the presence of the hardener was also confirmed. Using IR and Raman spectroscopy, the probable changes in the chemical structure of

the resin occurring during curing were described. It was found that the hardening of the resin was primarily evidenced by changes related to the decrease in the number of -N-H and -NH_2 bonds, the formation of methylene groups -CH_2- and, to a lesser extent, ether bridges -C-O-C-.

The formaldehyde-free resin-hardener systems that met all the assumed milestones, regarding the viscosity, stability and curing time, were subjected to four application evaluations: in the production of particleboards, for the impregnation of decorative papers on wood-based boards, in the coatings preparation on metal surface and in the production of core masses for the foundry industry. Due to the implementation nature of the doctoral thesis, the aim of the work was also to prepare and submit the patent application regarding the composition and method of synthesis of formaldehyde-free amine resins.